

**Sex Differences in the Attentional Networks: ERP Components and
Behavioural Indices**

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A report submitted in partial fulfilment of the degree of
Bachelor of Behavioural Science with Honours in Psychology

University of Tasmania

2015

Statement of Sources

I declare that this report is my own original work and that contributions of others have been duly acknowledged.

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Date _____

Acknowledgements

Firstly I would like to thank my supervisor Dr. Allison Matthews for her unwavering support, guidance and wisdom throughout this experience. You have made my year far less stressful and I am forever grateful. To all the members of the cognitive neuro lab, thank you for the laughs and pearls of wisdom you offered, most especially, Bethany Lusk and Professor Kim Felmingham. And thank you Emma Jackson and Lauren Reading for supplying chocolate and for making this experience that little bit better.

I would like to thank my research partners Amber Johnston and Shelley Flynn who shared the work load and put up with all my antics. Further thanks goes to my fellow psychology students, especially Abbie-Rose Imlach, Caitlin Walker and Thalia Papadakis who have encouraged and supported me through my university years. To my family, thank you for taking the brunt of my stress and loving me anyway. Thank you to my Dad, Phillip Hoysted for reading my assignments and helping whenever I asked. Thank you all for believing in me.

Finally, thank you to all those who participated in this study, your time and support are greatly appreciated.

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Word count: 9 983

Abstract

Sex differences associated with attentional processes have been evidenced in the academic literature, however, the research is limited. The current study aimed to clarify the inconsistencies regarding sex differences in attentional processes examining behavioural performance (RT) and neuronal indices of attentional networks using event related potentials (ERPs). The participants, 13 females and 15 males (mean age of 22.1 years) completed an attentional network task (ANT) to examine sex differences in the alerting, orienting and executive control networks (P1, N1 and N2 ERP components). The ANT involved an alerting condition followed by a cueing condition which included a valid, invalid and no cue trial. The cue either correctly or incorrectly indicated the spatial location of a following target that was either congruent or incongruent. Males had a trend for faster RT for no cue and invalid trials as well as greater N1 amplitudes, indicating an overall orienting effect. Sex differences in the P1 and N2 ERP components, while preliminary, suggest that there may be sex differences associated with the electrophysiological activity of the attentional networks. Importantly, sex differences in the interaction between the three networks warrants further research and may help to explain the findings of the current study.

There is substantial evidence that males and females differ in a number of cognitive functions. For example, it is generally agreed within the literature that males and females have different performance outcomes in visuospatial and verbal tasks (Bell, Willson, Wilman, Dave, & Silverstone, 2006; Neuhaus et al., 2009). In semantic-verbal tasks, such as the lexical word generation test, females perform at a higher level than males (Bell et al., 2005). In contrast, males show superior performance on visuo-spatial tasks, such as the mental rotation task, compared to females (Bell et al., 2005). The mechanisms behind sex-differences in cognitive functions are not fully understood, however, neuro-imaging studies looking at functional neuroanatomy have demonstrated greater right-prefrontal activation in females during mental rotation tasks. This pattern of cortical activation is thought to be indicative of top-down processing in visuo-spatial challenges (Butler et al., 2006; Hugdahl, Thomsen, & Ersland, 2006). Findings of this nature suggest that there may be sex differences in other cognitive functions that incorporate top-down processing such as selective spatial attention which is closely related to visuospatial cognition (Neuhaus et al., 2009). While different cortical activation patterns between the sexes have been consistently demonstrated, the spatiotemporal dynamics of the principal cortical events measured via event related potentials (ERPs) have not been evidenced definitively.

Petersen and Posner (2012) propose three fundamental concepts that underlie the attention system. Firstly, the attention system is anatomically separate to the information processing system. Secondly, the attention system encompasses a series of anatomical networks. Thirdly, these networks are argued to be functionally separate and can be specified in cognitive terms. They include the alerting network, the orienting network

and the executive control network and can be examined via behavioural and neuronal indices using an attentional network task (ANT).

Sex differences in the orienting network and the executive control network have been demonstrated using ANTs as well as alternative attentional paradigms (Stoet, 2010; Liu, Hu, Fan, & Wang, 2013). For example, males have shown a trend for faster RTs relative to females in research using ANTs (Liu et al., 2013; Neahuas et al., 2009). Additionally, odd ball tasks and flanker paradigms have demonstrated varying electrophysiological differences between males and females. However, the research is limited and the findings have been somewhat inconsistent. The current study aims to clarify the inconsistencies regarding sex differences in attentional functions as well as looking at the link between behavioural performance and electrophysiological indices, which has not been assessed conclusively.

The Attentional Networks

The mechanisms of attentional processes have been described according to a three-faceted system proposed by Petersen and Posner (2012). It is suggested that the attention system can be divided into three functionally and anatomically separate networks; the alerting, orienting and executive control networks. The alerting network involves arousal and heightened vigilance in preparation to respond to incoming information. The alerting system comprises the locus coeruleus, which is modulated by the hormone norepinephrine (NE). The NE pathway incorporates major nodes in the frontal cortex and areas of the parietal lobe which are involved in the dorsal visual pathways. The alerting system acts as a warning signal for the nervous system, and by

increasing alerting, target detection time is typically reduced (Fan, McCandliss, Sommer, Raz, & Posner, 2002).

The second network is the orienting network which allows the individual to allocate attentional resources to particular sensory inputs (modality or location). The orienting network includes a bilateral dorsal network including the frontal eye fields and interparietal sulcus, and a right lateralized ventral network including the temporoparietal junction and ventral frontal cortex (Petersen & Posner, 2012; Wright & Ward, 2008). The dorsal system mediates goal driven shifts in attentional resources, whereas the ventral network mediates reorienting of attention, such as when a target location is mislocated and the focus of attention needs to be shifted. The two networks are argued to work together to mediate attention shifts. For example, the temporoparietal junction (part of the ventral network) acts as a circuit breaker that interrupts processing of the interparietal sulcus (dorsal system) when disengagement is required to reorient attention to a target (Corbetta & Shulman, 2002).

The executive control system is the third network and is related to focal attention and top-down regulation. This network involves regulation of attention, conflict detection and resolution, and inhibition of irrelevant information (Petersen & Posner, 2012). Due to the processing of incoming information by the executive control network it has been argued that the network is involved in top-down regulation of attentional resources (Neuhaus et al., 2009). Two theories have been proposed to explain executive control. One theory focuses on the role of the anterior cingulate cortex (ACC) in conflict monitoring and resolution. Conflict monitoring involves the evaluation of current levels of conflict which signals compensatory adjustments in control processes (cognitive

control theory; Botvinick, Carter, Braver, Barch, & Cohen, 2001; Petersen & Posner, 2012). Conflict resolution involves the need to withhold a dominant response in order to perform a subdominant response (Botvinick et al., 2001). An alternative theory suggests two separate top-down control processes involving the ACC; one during task performance and the other at rest (Dosenbach, Fair, Cohen, Schlaggar, & Petersen, 2008; Dosenbach et al., 2007; Petersen & Posner, 2012). According to this dual network view (Dosenbach et al., 2007, 2008), the two executive systems work independently to maintain top-down control. The system that maintains task performance as a whole is controlled by a cingulo-opercular network. In contrast, a frontoparietal system is suggested to govern task initiation and adjustment (Petersen & Posner, 2012).

The Attention Network Task

Peterson and Posner's three attentional networks can be examined via behavioural and electrophysiological measures using an attentional network task (ANT; Fan et al., 2002) which is based on the covert cueing paradigm and flanker task (Eriksen & Eriksen, 1974; Fan et al., 2002; Posner, 1980). A covert cueing paradigm allows researchers to measure covert orienting of attention which is a shift in attention that involves internal mechanisms, independent of eye movement. Covert orienting of attention is indexed in this paradigm by benefits in reaction time when the spatial location of the target is expected and costs in reaction time when the spatial location of the target is unexpected (Posner, 1980). The flanker paradigm was developed by Eriksen and Eriksen (1974) to examine the influence of competing response options on attention (Clayson et al., 2011). The task involves congruent and incongruent trials whereby, during a congruent trial the flankers cue a response that is the same as the central target

stimulus (e.g., >>>>>), whereas, in an incongruent trial the flankers cue a response opposite to that of the central target (e.g., >><>>). Reaction times are typically faster in response to congruent trials compared to incongruent trials as focal attention is disrupted by the presence of incongruent distracters (Miller, 1991).

In the ANT, the alerting network is operationalised by an auditory tone that signals the beginning of half of the trials. The alerting effect is demonstrated when an individual responds faster to a target stimulus when there is a cue prior to the trial, exhibiting heightened arousal and readiness to respond (Fan et al., 2002).

The auditory tone is followed by a spatial cue that can be valid, neutral or invalid. A valid cue correctly indicates the spatial location of the following target stimulus whereas an invalid cue appears in the opposite spatial location to the proceeding target stimulus. A neutral cue can be a central cue (Neuhaus et al., 2009), a double cue that appears in both possible spatial locations of the proceeding target stimulus (Liu et al., 2013) or a no cue condition (Callejas, Lupianez, Funes, & Tudela, 2005). The orienting network is indexed by a benefit in RT to valid trials, and cost in RT to invalid trials, in comparison to neutral trials (Fan et al., 2002). Orienting effects have been demonstrated using an ANT, whereby participants responded faster to the spatial cue relative to the no cue condition. Additionally the central cue condition yielded faster responses than the no cue condition (Galvao-Carmona et al., 2014).

The executive control network is operationalised by a central target stimulus that is flanked either side by two images that are either congruent (a compatible image) or incongruent with the target. The executive control network is indexed by increased RT in response to an incongruent relative to a congruent target. This effect has been

demonstrated in research adopting both the ANT and flanker task (Clayson et al., 2011; Fan et al., 2002). Galvao-Carmona et al. (2014) used an ANT and found that participants were faster to respond to the congruent trials compared to the incongruent trials, demonstrating an executive control effect.

Electrophysiological correlates of attention

In addition to using behavioural measures to examine attentional networks, the neural activity associated with attention can also be measured using event related potentials (ERPs). ERPs are an index of the average electrical activity of the brain measured at the scalp, and are time locked to specific events or stimuli (Sur & Sinha, 2009). The early waveforms are related to sensory processes produced by the physical parameters of the incoming information. Conversely, the later waveforms reflect the process of evaluating the stimulus input and are associated with cognitive and top-down operations (Sur & Sinha, 2009). Three ERP components that are particularly relevant to the attentional networks are the early occipital and parietal N1 and P1, and the later frontal and parietal N2 ERP components.

P1 ERP Component. The P1 ERP component is associated with early visual attention and is often observed 100ms following the presentation of visual stimuli in the occipital and parietal regions (Abundis-Gutierrez, Checa, Castellanos, & Rueda, 2014). It has been suggested that variations in the peak amplitude of the P1 component are due to different levels of arousal and attention. Additionally, Mangun, Hillyard, & Luck (1993) suggested that the P1 component reflected the interpretation of form and colour of a visual stimulus, which aligns with the ventral ‘what’ pathway. The ventral ‘what’ pathway is argued to work in unison with the dorsal ‘where/how’ pathway in visual

processing, whereby the ventral pathway is suggested to encode the physical properties of the visual stimulus such as form and colour (Mangun et al., 1993).

Within the context of attentional paradigms P1 amplitude has been shown to increase for attended versus unattended stimuli and more specifically, is associated more with exogenous compared to endogenous cueing (Mangun & Hillyard, 1987). Research using an ANT found that the P1 amplitude was greater in response to spatial cues compared to no cue and central cue trials (Galvao-Carmona et al., 2014). Specifically, validly cued targets have been shown to elicit greater P1 amplitudes compared to invalid trials, indicating enhanced sensory processing (Abundis-Gutierrez et al., 2014; Wright et al., 1995)

Alternatively, P1 amplitude has been shown to increase in response to invalid trials relative to valid trials in endogenous and exogenous orienting of spatial attention. This occurs when inhibition of return is involved (Chica & Lupianez, 2009). Inhibition of return refers to the orienting mechanism whereby detection speed and accuracy is momentarily impaired. Increases in P1 amplitudes due to inhibition of return in invalid trials generally occur in tasks with longer stimulus onset asynchronies (> 300 ms; Posner & Cohen, 1984). As modulations in the P1 amplitude are largely in response to valid trials and there are no behavioural sex differences associated with this type of cue, there may also be no sex difference in the P1 component.

N1 ERP Component. The N1 ERP component is a negative component of the ERP waveform peaking from 100-200ms after stimulus onset (Sur & Sinha, 2009). The N1 indexes neural activity during early sensory processing (Neuhaus et al., 2009). In paradigms looking at the orienting network, such as the ANT, covert orienting tasks and

odd ball tasks, an increase in the N1 amplitude in response to trials without a valid cue have been documented. It has been suggested that increases in the N1 amplitude are due to the presentation of unexpected visual stimuli, whereby the individual is required to reorient their focal attention (Galvao-Carmona et al., 2014; Sur & Sinha, 2009; Wright et al., 1995). Additional research has proposed that modulations in the N1 amplitude reflect discrimination processes (Vogel & Luck, 2000). In contrast to the first theory, the N1 discrimination effect hypothesis suggests that greater negativity in N1 amplitude reflects the operation of discriminating a stimulus that is in the current focus of attention. However, research looking at the orienting network using the ANT and other discrimination paradigms (such as the oddball task) have found increased N1 amplitude in response to trials without a valid cue, which means the target was not in focal attention (Galvao-Carmona et al., 2014; Neuhaus et al., 2009; Wright et al., 1995). For example, Wright, Geffen, and Geffen (1995) examined covert orienting in a spatial cueing paradigm. The researchers found that the N1 amplitude was increased in response to invalidly cued targets relative to valid and no cue trials. These findings support the notion that the N1 amplitude reflects re-orienting of attention rather than discrimination processes of current focal attention (Wright et al., 1995).

The increased cost in RT and increased N1 amplitude to neutral and central cues described in the literature may indicate the need to reorient or move the attentional focus from the cue to the target location when it is not validly cued (Galvao-Carmona et al., 2014; Wright et al., 1995). Alternatively, it has been suggested that participants take longer to respond to a target stimulus when their attentional focus is global rather than local (Galvao-Carmona et al., 2014; McConnell and Shore, 2011). For example, in a

correctly cued trial the attentional focus is concentrated to a specific location, whereas for neutral cues (such as double cue or no cue) the attentional focus is spread across all possible spatial locations of the proceeding target stimulus (Fan et al., 2002; McConnell and Shore, 2011). Importantly, the N1 amplitude has been shown to increase in response to stimuli that require a larger spread of the visual field for visual perception than for a more focused attention (Benwell, Thut, Grant, & Harvey, 2014; Galvao-Carmona et al., 2014; Snyder, Gregg, Weintraub, & Alain, 2012). These findings suggest that there may be greater N1 amplitude for invalid and neutral trials relative to valid cues. The literature, however, is not clear and links between electrophysiological measures (such as the P1 and N1 components) and behavioural indices have not been conclusively documented regarding the orienting network.

N2 ERP Component. The N2 ERP component is a fronto-central negative deflection of the ERP waveform peaking 200-400ms post stimulus. The N2 component is an indicator of endogenous or cognitive processes (Sur & Sinha, 2009) which is thought to index processing of irrelevant information and conflict monitoring and resolution. The N2 amplitude is greater (more negative) in response to high-conflict compared to low conflict information or stimuli (Botvinick et al., 2001; Clayson et al., 2014; Dickter & Bartholow, 2010). Anatomically, the conflict control processes related to monitoring and regulation is suggested to occur in the dorsolateral prefrontal cortex and ventrolateral prefrontal cortex, whereas evaluative control processes originate in the ACC (Etkin, Egner, & Kalisch, 2011; Larson, Clayson & Clawson, 2014). It is argued that the ACC detects conflict and then signals for changes in control from the dorsolateral and ventrolateral prefrontal cortex. It is suggested that the neural activity of

the ACC is reflected in the frontal N2 ERP component (Ridderinkhof et al., 2004; van Veen & Carter, 2002; Yeung et al., 2004). Importantly, sex differences in the markers of ACC activation have been demonstrated, suggesting that there are also sex differences in the parameters that control the N2 component, such as attention.

In addition to a frontal N2 ERP, a parietal N2 component (N2p) may be elicited which is thought to reflect target discrimination during visual search and the process of stimulus classification (Dowdall, Luczak, Tata, 2012). Importantly, attentional tasks such as the visual pop out task, have demonstrated that the N2p is present only in target present trials. Additionally, the N2p has been shown to increase in response to trials when there are distracters present, such as in visual search paradigms (Conci, Gramann, Muller, & Elliott, 2006).

Sex Difference in the Attentional Networks

Sex differences in the orienting network have been demonstrated using a number of different attentional paradigms, including endogenous cueing paradigms which involve a central cue and exogenous cueing paradigms which involve peripheral spatial cues. Merritt et al. (2007) used an endogenous cueing paradigm to assess whether males and females differ in their selective attention ability. The results of the study showed that there was a gender difference in response to differently cued trials, whereby females incurred a cost in RT for invalidly cued trials compared to no cue trials, while males showed a benefit in RT. Similarly, Liu et al. 2013 also found a sex difference in the orienting network, such that, in response to an exogenous spatial cue compared to a central cue, females had a greater orienting effect than males. However, it is not clear whether this effect was because females responded faster to the validly cued target or

whether, similar to the findings of Merritt et al., females responded slower to invalidly cued trials. Furthermore, Neuhaus et al. (2009) found a statistical trend for slower RTs in female participants compared to males in an ANT.

Additional research using electrophysiological methods to examine sex differences in the orienting effect have found similar results. Neuhaus et al. (2009) used the ANT to analyse ERP components and found greater N1 amplitude in response to targets cued by neutral (i.e., double) cues in females compared to males. Research into the orienting network using alternative paradigms also found similar results. Vaquero, Cardoso, Vazquez, and Gomez (2004) used an oddball task to demonstrate that females had greater N1 amplitudes than males when discriminating a target. Due to the finding that females have a slower RT and greater N1 amplitude in response to incongruent trials, it has been suggested that females attend more to cues than males and therefore less efficiently reorient their attention to a target stimulus relative to males, resulting in slower RTs and greater N1 amplitudes (Merritt et al., 2007). However, the research using an ANT to examine the orienting network is inconclusive and further examination of the relationship between behavioural and neuronal indices could aid in clarification.

The executive control network was examined by Liu et al. (2013) who found no sex differences in RT to incongruent stimuli using an ANT. Importantly, previous research has not examined the N2 component using an ANT. Alternatively, in research using flanker tasks it has been found that females have a slower RT in response to incongruent stimuli compared to males and that males yielded greater N2 amplitudes in the incongruent trials compared to females (Clayson et al., 2011). Similar findings have

been demonstrated by Stoet et al. (2010) using a combined go/no-go and flanker task, whereby females responded slower to incongruent trials.

A number of different mechanisms behind these findings have been suggested. Stoet et al. (2010) proposed that females' poorer performance compared to males was due to a greater distraction by irrelevant information, therefore females were less able to focus and respond to the target. In a similar vein, Clayson et al. (2011) suggested that the combination of attenuated N2 amplitude and slower RT in females may be indicative of less effective recruitment of attentional resources. Alternatively, it may be that the greater N2 amplitude seen in males is due to the fact that males require greater attentional resources in conflict monitoring. In other words, to complete a cognitive task at similar performance levels, females need less neural activation than males. Clayson et al. also found that females had shorter N2 latencies compared to males which supported the idea that females, relative to males, were more efficient at processing conflicts.

Additional research in the attentional field examining behavioural and cognitive indices such as ERPs found that while males and females had similar behavioural outcome performances, neural activation was greater and more widely spread in males (Li, Huang, Constable, & Sinha, 2006; Li et al., 2009; Hester et al., 2004). More specifically, greater neural activation occurred in frontal regions of the brain associated with the N2 ERP component, such as the ACC (Clayson et al., 2011). This may indicate that males and females recruit neural networks to different extents in order to accomplish similar performance on behavioural tasks. Li et al. concluded that males required more neural resources for inhibitory responses which are incorporated in the executive control network. The varying results regarding the executive control network

highlight the limited and inconsistent research that is currently in the literature and the need for future research. The current research using ANTs to examine sex differences in the attentional networks have not found sex differences in RT on alerting and non-alerting trials, suggesting that there may not be a sex difference in the alerting network (Liu et al., 2013; Neuhaus et al., 2000).

Rationale, Aims and Hypotheses

In summary, there is substantial evidence to suggest that males and females differ in the attentional networks, however, the mechanisms responsible for this effect are not well understood. Sex differences in both behavioural and electrophysiological indices have been evidenced, but the relationship between them has not been assessed conclusively. The current study aims to clarify the inconsistency within the literature regarding sex differences in the attentional networks. The study also aims to explore the relationship between behavioural performance and neuronal indices of the attentional networks. Consistent with findings in research using ANTs and cueing paradigms, it is hypothesised that females will show a greater overall orienting effect compared to males, indexed by greater costs to RT in invalid trials compared to neutral trials. Additionally, it is hypothesised that females will be less efficient at reorienting attention, indexed by greater N1 ERP component amplitude, in response to invalid trials compared to males. Due to the lack of evidence to suggest sex differences in the P1 amplitude in an ANT, no difference between males and females is predicted. Based on the findings of Clayson et al. (2011) it is hypothesised that females will demonstrate a greater flanker effect as indexed by increased RT on incongruent compared to congruent trials, and a reduction in inhibitory processing as indexed by attenuated N2 amplitude on

incongruent relative to congruent trials. Based on the lack of evidence to suggest sex differences in the alerting network using an ANT, the current study predicts no difference in the alerting effect between males and females.

Method

Participants

This study was approved by the University of Tasmania Human Research Ethics Committee (see Appendix A). The final sample consisted of 28 participants, aged between 18 and 35 recruited from the first year psychology undergraduate program at the University of Tasmania as well as acquaintances of the experimenters. First year psychology students who participated were given two hours course credit.

Standard ERP exclusion criteria were applied in the screening process (see Appendix B), whereby participants with high levels of psychological distress (Kessler Psychological Distress scale (K10) score greater than 30), a history of medical or neurological disorders, use of prescription medications (other than contraception), more than monthly illicit drug use (three participants had used illicit drugs more than 15 times in their life time), and high alcohol users (The Alcohol use Disorders Identification test (AUDIT) score greater than 16) were excluded from the study. Participants were asked to abstain from alcohol consumption 24 hours prior to testing and caffeine and nicotine 2 hours before testing. One participant in the female group was on psychoactive medication, and none in the male group.

Following the experimental session four participants (two females and two males) were excluded due to accuracy rates that were less than 65% in at least one cell. Additionally, due to errors in the experimental protocol, two female participants were

excluded from the final sample. The final sample included 13 females and 15 males with a mean age of 22.1 years ($SD=3.86$, range=19-34). All participants were studying at a tertiary level or had completed secondary education. All participants were right handed except one participant who was ambidextrous. All participants spoke fluent English and had normal/corrected-to-normal vision.

Materials

State Trait Anxiety Inventory Form Y-2 (STAI; Spielberger, 1983). The STAI was used to measure trait anxiety. It is a 20 item self report inventory that evaluates levels of stress, worry and discomfort. Participants responded to a 4-point Likert scale (1=almost never, 2=sometimes, 3=often, 4=almost always) to indicate how they generally feel (e.g., “*I feel nervous and restless*”) whereby higher scores are positively correlated with higher levels of anxiety (Spielberger, 1983). The STAI has been shown to have good internal consistency with a Cronbach’s alpha of 0.86 (American Psychological Association, 2015). Additionally, the test re-test reliability of the STAI has been shown to be good and adequate validity (Oei, Evans, & Crook, 1990).

Wechsler Test of Adult Reading (WTAR; Wechsler, 1958). The WTAR was used as an estimate of verbal intelligence. The WTAR is a neuropsychological assessment tool designed for English speaking individuals. Participants were required to read out a list of 50 irregularly spelled words to the experimenter, the test is discontinued if there are 12 consecutive mispronunciations. The raw scores are then standardised for age and compared to the predicted scores for their demographic (Wechsler, 1958). The WTAR has been shown to have good convergent validity with other current measures of general verbal intellectual ability and good discriminant validity, such that it did not correlate

highly with measures of learning and memory (Green et al., 2008; Whitney, Shepard, Mariner, Mossbarger, & Herman, 2010).

The Alcohol use Disorders Identification test (AUDIT; Babor, Higgins-Biddle, Saunders, & Monteiro, 2001). The AUDIT was used as a validated ten question test designed to assess whether a person's alcohol consumption was harmful. Participants with a score greater than 16 were excluded (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001). Research has demonstrated good test-retest reliability with a Spearman correlation coefficient of 0.88 and good internal consistency with a Cronbach's alpha of 0.85 (Daeppen, Yersin, Landry, Pecoud, & Decrey, 2000).

Kessler Psychological Distress scale (K10; Kessler et al., 2002). The K10 is a ten item screening scale designed to measure non-specific psychological distress over the preceding four weeks. Participants were asked to indicate their response to each item (e.g., "*Did you feel tired out for no good reason*") from 1 (all of the time) to 5 (none of the time). Scores of greater than 30 are considered to indicate high levels of psychological distress (Kessler et al., 2002).

Computer Gaming Experience form. The participants' engagement in computer gaming was measured on a questionnaire designed by the author with responses ranging on a 5 point scale from '*Never play video games*' to '*Often play video games (more than five times a week)*' (see Appendix C).

Menstrual Cycle form. The female participants' menstrual cycle stage was recorded as determined by day from the first day of their last period (luteal, follicular, or late follicular) (see Appendix C).

Attention Network Task (ANT). The task was adapted from Callejas et al. (2005) and was presented using NeuroScan STIM 3.1 software. There were a total of 384 trials divided evenly into four blocks, with each level of each condition presented evenly (32 trials) in a randomised order with equal probability in the left or right visual field. Each trial began with the presentation of a central cross which was presented for a variable interval of 400, 600, 800, or 1200 ms in a randomised order. Following this, an auditory tone (2000 Hz, 50ms) was used to indicate the beginning of half the experimental trials in a randomised sequence. After a 400ms interval a spatial cue was presented. The cue was an asterisk (0.4cm diameter, presented for 100ms) that appeared in the same location as the following target stimulus (valid trial), in a different location (invalid cue) or was not presented (no cue). The flanker target stimulus followed the spatial cue after a 50ms interval and was presented for 1700ms or until a response was made. The target was a white arrow head on a black background that pointed to the left or right and was flanked on both sides by two arrow heads pointing in the same direction (congruent condition) or by arrow heads pointing in the opposite direction (incongruent condition). The target stimulus was presented 1cm from the fixation cross and was 2cm in length and 0.5cm in height.

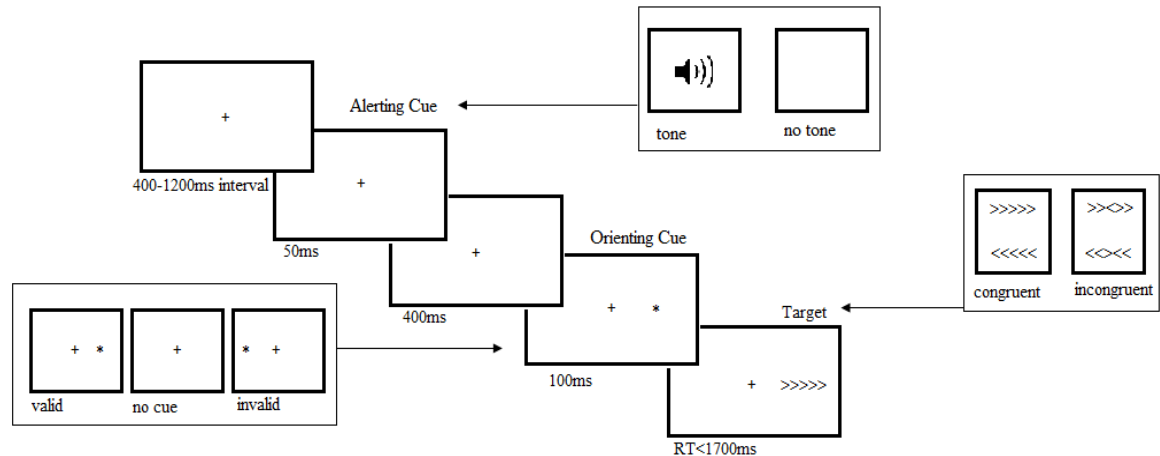


Figure 1. Experimental paradigm of the ANT (procedure and stimuli).

Electrophysiological (EEG) recording. A NeuroSCAN system (Scan 4.4 system) and 32-channel Synamps and Quik-Cap with Ag/AgCl sintered electrodes were employed. The international 10-20 system of electrode placement was used to record continuous electroencephalographic (EEG) data from 32 sites. Electrode impedance was kept below 5k Ω . Data was sampled continuously at a rate of 1000Hz. Standard skin preparation procedures were followed. Electrodes were placed above and below the left eye and on the outer canthi of both eyes to measure vertical and horizontal electro-oculographic (EOG) activity respectively and all electrodes were referenced to linked mastoids.

The editing process began by merging continuous EEG files with the behavioural files which were then filtered using a Zero-phase-shift low-pass filter (30Hz, 24dB/Oct). To attenuate the influence of eye blinks across electrodes, ocular artefact reduction was performed. The data was then Epoched from 200ms before

stimulus onset to 800ms post. Artefact rejection and baseline correction was then carried out whereby trials with artefacts above 70 μ V and below -70 μ V were rejected. The P1 component was determined from grand mean average waveforms as the maximum amplitude 60-110ms after stimulus onset. The occipital and parietal N1 component was determined from the grand averaged waveforms as the minimum amplitude 110-160ms after stimulus onset. The parietal N2 component was determined from grand mean average waveforms as the minimum amplitude 160-220ms after stimulus onset.

Data Analysis and Design.

The behavioural dependant variables of mean RT (ms) and mean accuracy (percent of correct trials) were analysed using a 2(Sex: male, female) \times 2(Alerting: yes, no) \times 3(Cue: valid, neutral, invalid) \times 2(Congruency: congruent, incongruent) mixed ANOVA.

Peak amplitude of the P1, N1 and N2 ERP components were analysed using a 2(Sex: male, female) \times 2(Alerting: yes, no) \times 2(Cue: valid, invalid) \times 2(Congruency: congruent, incongruent) \times 2(Hemisphere: left, right) \times 2(Site: parietal, occipital) mixed ANOVA. The analyses of the peak amplitudes was conducted for valid and invalid cues but not no cue trials. This analysis was chosen because no cue trials produced wave forms that were dissimilar to valid and invalid trials due to the lack of an orienting cue. As such, the wave forms were not comparable. Analysis of P1 and N1 amplitude was confined to the occipital and parietal sites O1 (left hemisphere), O2 (right hemisphere), P3 (left hemisphere) and P4 (right hemisphere). Analysis of N2 amplitude was confined to the parietal sites P3 (left hemisphere) and P4 (right hemisphere) as there was no clear N2 component elicited at frontal sites in the present study. Only the theoretically

relevant significant interactions ($p < .05$) were further investigated with break down ANOVAs and analysis of simple effects. To control for inflated family wise error rates Bonferroni corrections were made for tests of simple effects. Partial eta square (η_p^2) was reported as a measure of effect size for omnibus ANOVAs. For the analysis of simple main effects, Hedges' g was used as an effect size to improve α bias, and was interpreted using Cohen's (1988) convention (.2=small, .5=medium, .8=large). Mixed measures ANOVAs were chosen for consistency with previous research using ANT tasks group (Abundis-Gutierrez et al., 2014) and because they allowed for the examination of main effects as well as higher order interactions between attentional networks, hemisphere and site variables, and those involving Sex.

Procedure

Participants completed the screening process using a secure online survey (SONA) which included a demographic questionnaire and the SPQ, FSQ and AUDIT. Eligible participants were then invited to attend a two hour experimental session and were offered two hours course credit if they were a first year psychology student. After participants had given informed consent (see Appendix D) they completed the STAI, WTAR, and rated their video gaming experience. Additionally, female participants were asked to provide details about hormonal contraception and menstrual cycle phase (see Appendix B). Participants were then set up for EEG recording and seated 50cm from the computer screen. Participants began by completing a dot probe task (10mins) followed by two ANTs in a counterbalanced order; each took 30 minutes to complete with four experimental blocks and one practice block of ten trials. Participants had short breaks between each block and a longer one between the ANTs in which they were encouraged

to have a glass of water and stretch to minimise fatigue. For the ANT used in the present study, participants were asked to respond as quickly and accurately as possible to the direction of central target stimulus using a two choice button press while ignoring irrelevant information. Participants responded to the target by pressing a button with their right index finger when the target arrow was pointing to the right and responded using their left index finger when the target arrow pointed to the left. At the end of the session participants were debriefed.

Results

Demographics

Table 1 displays the mean age of participants and mean scores on the psychological distress (K10), verbal intelligence (WTAR), gaming and menstrual cycle measures. There was no significant difference between groups for age, AUDIT and WTAR scores, trait anxiety at time of testing, and gaming levels. A chi-square test of independence was used to examine the gaming scores, it was found that males were more likely (40%) to report that they ‘often’ played video games compared to females (8%), $X^2(2, N=28)=9.41, p=.009$.

Table 1.

Mean age of participants and scores on the psychological distress, intelligence and alcohol inventories.

	<u>Females(n=13)</u>	<u>Males(n=15)</u>			
	<i>M(SD)</i>	<i>M(SD)</i>	<i>F(1,26)</i>	<i>p</i>	Hedges <i>g</i>
Age	21.08 (4.1)	22.9 (3.6)	1.65	.210	.460
K10	17.2 (4.5)	14.6 (4.2)	2.55	.123	.581
AUDIT	4.9(2.9)	5.8(3.2)	0.54	.470	.285
STAI	34.8(5.0)	33.1(6.0)	0.60	.446	.297
WTAR	38.7(3.5)	40.8(3.8)	2.33	.139	.556

Behavioural results

Reaction time (RT). A significant main effect of Alerting was found, $F(1, 26)=88.50$, $p<.001$, $\eta_p^2=.773$, whereby RT (ms) was significantly faster to the alerting tone condition ($M=582$, $SD=55.2$) compared to no alerting tone condition ($M=606.9$, $SD=57.1$). However, there was no significant interaction of Alerting \times Sex interaction, $F(1, 26)=.457$, $p=.505$, $\eta_p^2=.017$.

There was a significant main effect of Cue, $F(1,52)=147.08$, $p<.001$, $\eta_p^2=.850$, whereby valid cues ($M=559.9$ $SD=58.3$) had significantly faster RTs than no cues ($M=596.2$, $SD=56.7$), $p<.001$, and invalid cues ($M=627.2$, $SD=56.1$), $p<.001$. Additionally, RT to no cues were significantly faster than RT to invalid cues, $p<.001$.

Further, there was a significant Cue \times Sex interaction, $F(2, 52)=3.30$, $p=.045$, $\eta_p^2=.113$ (see Figure 2). Pair-wise comparisons showed that there were no significant differences between males and females for all trial types ($p>.05$). However, there were moderate effect sizes for invalid (Hedges $g=0.561$) and no-cue trials (Hedges $g=0.513$).

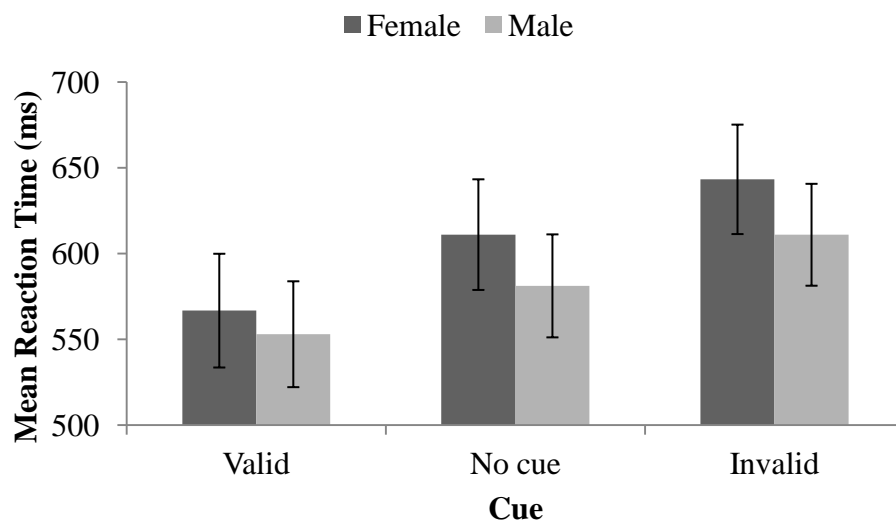


Figure 2. Mean RT for valid, invalid and no cue trials among males and females (error bars represent 95% CIs).

A significant main effect of Congruency was found, $F(1, 26)=588.85$, $p<.001$, $\eta_p^2=.958$, whereby RT was faster in congruent trials ($M=481.15$, $SD=50.22$, 95% CI[461.94,500.66]) compared to incongruent trials ($M= 707.68$, $SD=70.09$, 95% CI[680.46,734.91]). However, the Congruency \times Sex interaction was non-significant, $F(1,26)=.845$, $p=.367$, $\eta_p^2=.031$. Additionally, the Alerting \times Cue \times

Congruency \times Sex interaction was approaching significant, $F(1,26)=3.18$, $p=.05$, $\eta_p^2=.109$. There were no other significant higher order interactions ($p>.05$) involving sex. There were additional significant higher order interactions that did not involve sex, and thus were not theoretically relevant and were not reported.

Accuracy. There was a significant main effect of Congruency, $F(1,26)=18.46$, $p<.001$, $\eta_p^2=.415$. The percentage of correct responses was significantly greater for congruent trials ($M=98.69$, $SD=2.33$) compared to incongruent trials ($M=94.5$, $SD=5.11$). Additionally, there was a significant Cue \times Congruency interaction, $F(2,52)=3.25$, $p=.047$, $\eta_p^2=.111$. Pair-wise comparisons showed that for valid cues accuracy was significantly greater in congruent ($M=99.03$, $SD=1.93$, 95%CI[8.28,99.78]) compared to incongruent trials ($M=94.66$, $SD=5.30$, 95%CI[92.60,96.72]), $p<.001$, Hedges $g=1.08$. Further, for invalid cues accuracy was significantly greater for congruent ($M=98.79$, $SD=3.41$, 95%CI[97.46,100.11]) relative to incongruent trials ($M=94.96$, $SD=5.33$, 95%CI[92.89,97.04]), $p=.002$, Hedges $g=.844$. Lastly, for no cues the percentage of correct responses was significantly greater for congruent ($M=98.27$, $SD=2.35$, 95%CI[97.36,99.18]) relative to incongruent trials ($M=93.86$, $SD=6.10$, 95%CI[91.49,96.23]), $p<.001$, Hedges $g=.941$.

The Alerting \times Cue \times Congruency \times Sex interaction was significant, $F(2,52)=3.96$, $p=.025$, $\eta_p^2=.132$. An analysis of simple interaction effects showed that the Congruency \times Alerting \times Sex interaction was significant ($\alpha=.025$, Bonferroni adjusted) for invalid trials, $F(1,26)=9.658$, $p=.005$, $\eta_p^2=.271$ (see Figure 3). Further analysis demonstrated that for the non-alerting, invalid trials the Congruency \times Sex

interaction was approaching significant, $F(1,26)=4.548$, $p=.043$, $\eta_p^2=.149$. An analysis of simple effects ($\alpha=0.016$, Bonferroni adjusted) showed that males had a significant effect of congruency for non-alerting, invalid trials, $F(1,14)=11.05$, $p=.005$, $\eta_p^2=.441$, whereas females did not, $F(1,12)=0.062$, $p=.808$, $\eta_p^2=.005$ (see Figure 3). However, accuracy was greater than 90% for all conditions.

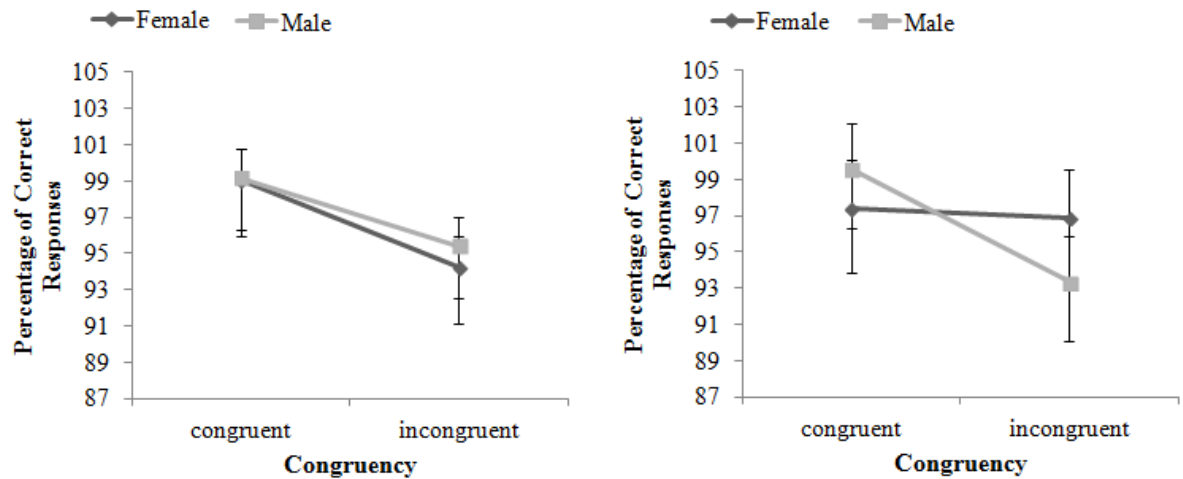


Figure 3. Percentage of correct responses for males and females in alerting (left) and non-alerting (right), invalid trials, for congruent and incongruent targets (error bars represent 95% CIs).

Electrophysiological results

Figure 4 and 5 show grand mean averaged wave forms for males and females at occipital sites O1 and O2, and parietal site P3 and P4. Figure 4 shows that females had greater P1 amplitudes at the right occipital site for invalid congruent trials compared to other conditions. Figure 5 shows that males had greater N1 amplitudes at parietal sites for incongruent trials.

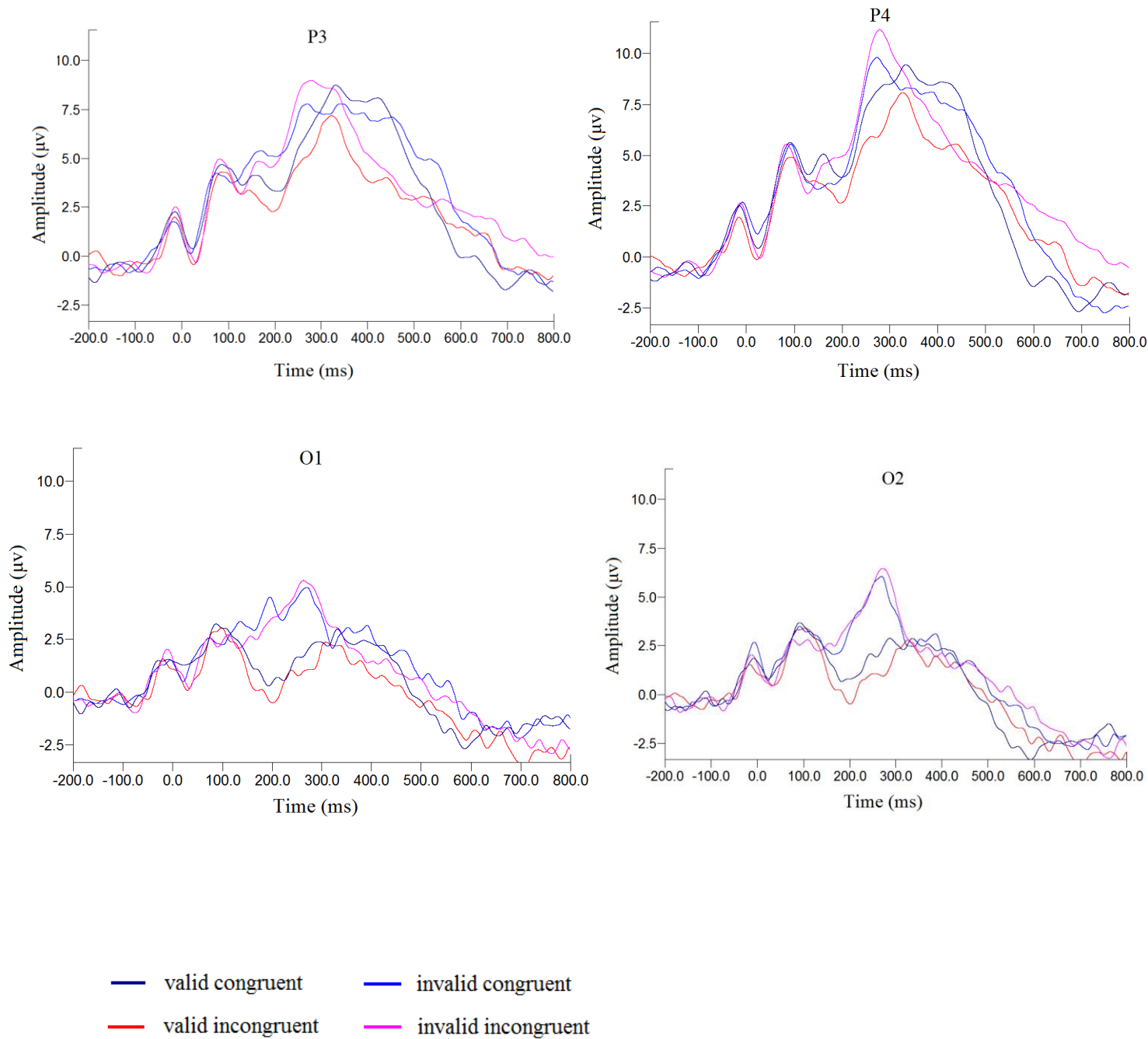


Figure 4. Grand mean averaged wave forms for female participants at parietal P3 (left) and P4 (right), and occipital O1 (left) and O2 (right) sites for cueing and congruency conditions

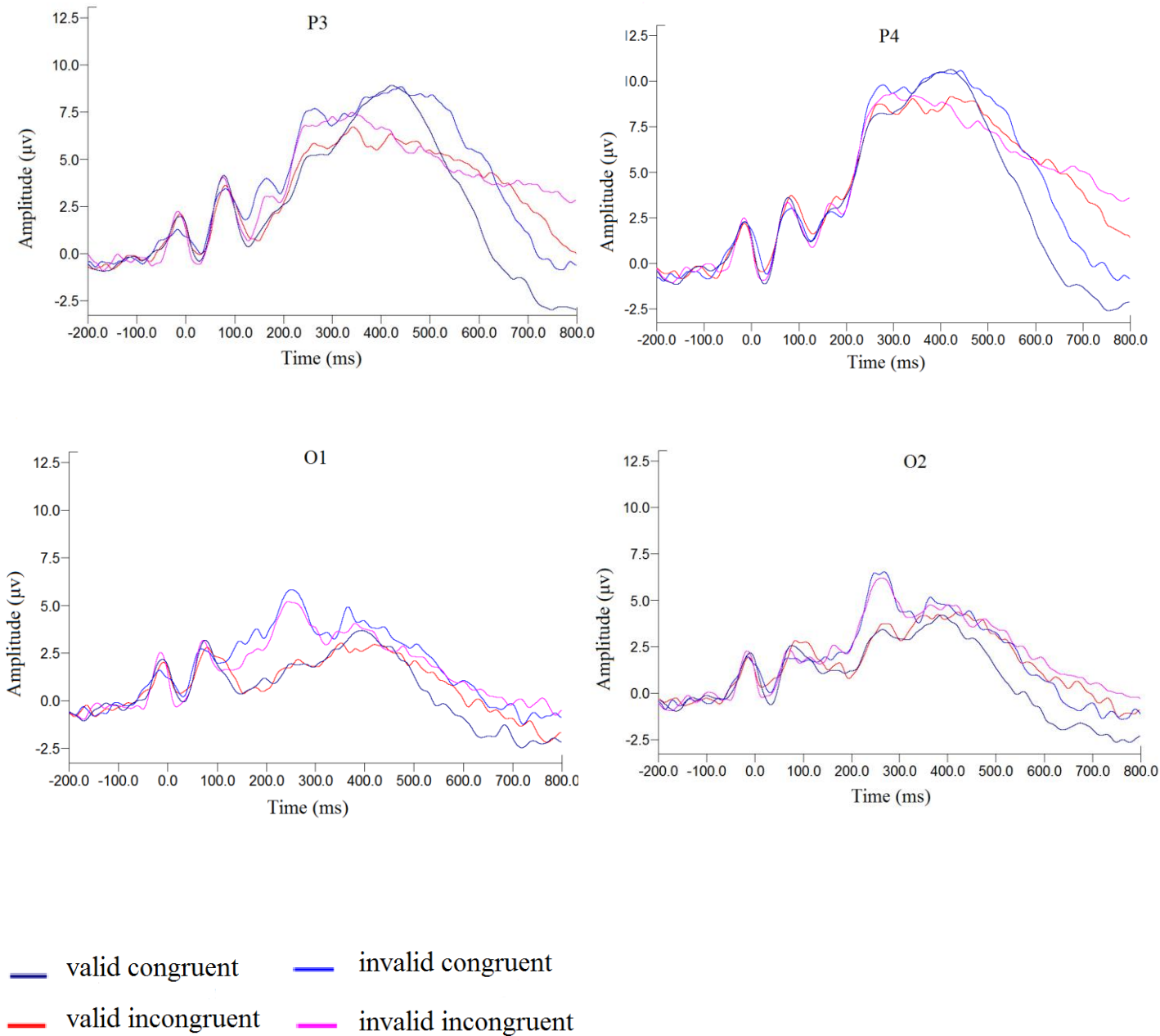


Figure 5. Grand mean averaged wave forms for male participants at parietal P3 (left) and P4 (right), and occipital O1 (left) and O2 (right) sites for cueing and congruency conditions.

Peak P1 amplitude. The main effect of Site was significant, $F(1,26)=15.50$, $p=.001$, $\eta_p^2=.373$. However the Site \times Sex interaction was non-significant, $F(1,26)=1.82$, $p=.189$, $\eta_p^2=.065$. The main effect of Alerting was non-significant, $F(1,26)=0.419$, $p=.523$, $\eta_p^2=.016$, as was the Alerting \times Sex interaction, $F(1,26)=1.72$, $p=.202$, $\eta_p^2=.062$. The main effect of Cue, $F(1,26)=0.015$, $p=.902$, $\eta_p^2=.001$ and the the Cue \times Sex interaction, $F(1,26)=0.45$, $p=.510$, $\eta_p^2=.017$, were both non-significant. The main effect of Congruency was non-significant $F(1,26)=0.28$, $p=.600$, $\eta_p^2=.011$, as was the Congruency \times Sex interaction, $F(1,26)=0.10$, $p=.757$, $\eta_p^2=.004$. Similarly, the main effect of Hemisphere, $F(1,26)=0.26$, $p=.615$, $\eta_p^2=.010$, and the Hemisphere \times Sex interaction, $F(1,26)=2.18$, $p=.152$, $\eta_p^2=.077$, were both non-significant.

There was a significant Congruency \times Site \times Sex interaction, $F(1,26)=4.46$, $p=.044$, $\eta_p^2=.146$, which was modified by a significant Hemisphere \times Cue \times Congruency \times Site \times Sex interaction, $F(1,26)=4.508$, $p=.043$, $\eta_p^2=.148$. Separate analyses at occipital and parietal sites showed that the Cue \times Congruency \times Hemisphere \times Sex interaction was significant at occipital sites, $F(1,26)=9.22$, $p=.005$, $\eta_p^2=.262$, such that there was a significant Congruency \times Hemisphere \times Sex interaction on invalid trials, $F(1,26)=16.14$, $p<.001$, $\eta_p^2=.383$ (see Figure 6).

Further examination of this interaction showed that at occipital sites for invalid, congruent trials there was a significant Hemisphere \times Sex interaction, $F(1,26)=9.16$, $p=.006$, $\eta_p^2=.260$. At the right hemisphere occipital site (O2) the effect of Sex was approaching significant for invalid, congruent trials with a moderate effect size, $F(1,26)=3.15$, $p=.088$, $\eta_p^2=.108$, *hedges g* = 0.65, whereby females had greater P1 amplitude compared to males. However, at the left hemisphere occipital site (O1) the

effect of Sex was non-significant with a small effect size, $F(1,26)=0.04$, $p=.852$, *Hedges* $g=0.07$, whereby females had a slightly larger P1 amplitude compared to males.

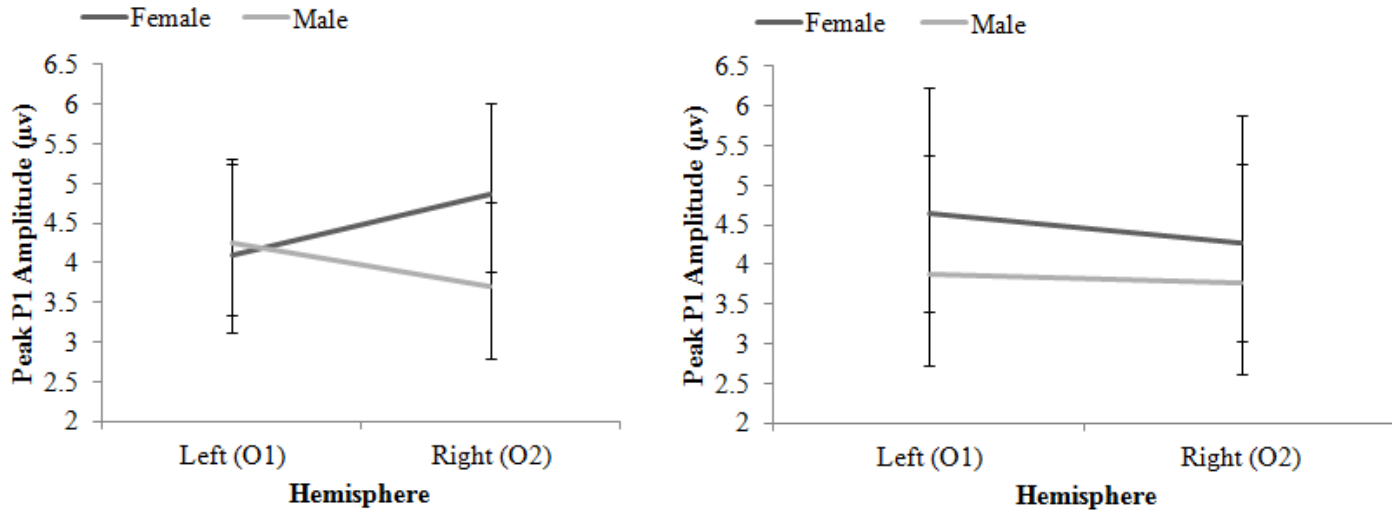


Figure 6. Peak P1 amplitude for congruent (left) and incongruent (right) trials in the right and left hemisphere occipital sites for females and males (error bars represent 95% CIs).

Peak N1 Amplitude. There was a significant main effect of Site, $F(1,26)=8.351$, $p=.008$, $\eta_p^2=.243$, whereby N1 amplitude was significantly greater at occipital sites ($M=-0.022$, $SD=2.13$) compared to parietal sites ($M=0.710$, $SD=2.48$). Additionally, there was a main effect of Alerting, $F(1,26)=12.394$, $p=.002$, $\eta_p^2=.323$, whereby, the N1 amplitude was significantly greater for alerting trials ($M=-0.081$, $SD=2.26$) compared to non alerting trials ($M=0.769$, $SD=2.34$). This main effect was modified by a significant Alerting \times Hemisphere interaction, $F(1,26)=4.88$, $p=.036$, $\eta_p^2=.158$. Analysis of simple

main effects ($\alpha=.025$, Bonferroni adjusted) demonstrated that in the left hemisphere, there was a significant main effect of Alerting, $F(1,26)=14.78$, $p=.001$, $\eta_p^2=.362$, whereby, N1 amplitude was significantly greater on alerting ($M=-.320$, $SD=0.44$, 95%CI[-1.23,0.59]) compared to non alerting trials ($M=.767$, $SD=0.49$, 95%CI[-0.24,1.78]), Hedges $g=.433$. Additionally, there was a significant main effect of Alerting in the right hemisphere, $F(1,26)=6.28$, $p=.019$, $\eta_p^2=.195$, whereby, N1 amplitude was significantly greater on alerting ($M=0.16$, $SD=2.55$, 95%CI[-0.83,1.15]) compared to non alerting trials ($M=0.77$, $SD=2.36$, 95%CI=-0.15,1.69]), Hedges $g=.246$. There was also a significant main effect of Congruency, $F(1,26)=4.585$, $p=.042$, Hedges $g=0.136$, whereby, incongruent trials elicited greater N1 amplitudes ($M=0.189$, $SD=2.22$) compared to congruent trials ($M=0.499$, $SD=2.26$).

Further, there was a significant main effect of Cue, $F(1,26)=10.268$, $p=.004$, $\eta_p^2=.283$, whereby, there was a significantly greater N1 amplitude for valid trials ($M=-0.157$, $SD=2.52$) compared to invalid trials ($M=0.845$, $SD=2.20$). However the Cue \times Sex interaction was non-significant, $F(1,26)=0.02$, $p=.902$, $\eta_p^2=.001$. The main effect of Cue was modified by a significant Cue \times Hemisphere interaction, $F(1,26)=14.95$, $p=.001$, $\eta_p^2=.365$. Analysis of simple main effects ($\alpha=.025$, Bonferroni adjusted) showed that the main effect of Cue was significant in the left hemisphere, $F(1,26)=17.55$, $p<.001$, Hedges $g=.546$, whereby valid cues produced greater N1 amplitudes ($M=-.47$, $SD=2.68$, 95%CI[-1.51,0.57]) compared to invalid cues ($M=0.92$, $SD=2.35$, 95%CI[0.01,1.84]). Conversely, the main effect of Cue was non-significant in the right hemisphere, $F(1,26)=3.51$, $p=.071$, Hedges $g=.238$.

The Sex \times Site interaction was significant (see Figure 7), $F(1,26)=11.45$, $p=.002$, $\eta_p^2=.306$. Analysis of simple main effects demonstrated that the effect of Sex was non-significant at occipital sites, $F(1,26)=0.18$, $p=.674$, Hedges $g=.125$, but approached significance at parietal sites ($\alpha=.025$, Bonferroni adjusted), $F(1,26)=4.82$, $p=.037$, Hedges $g=0.645$, whereby males had greater N1 amplitudes ($M=-.319$, $SD=3.38$) compared to females ($M=1.74$, $SD=2.47$).

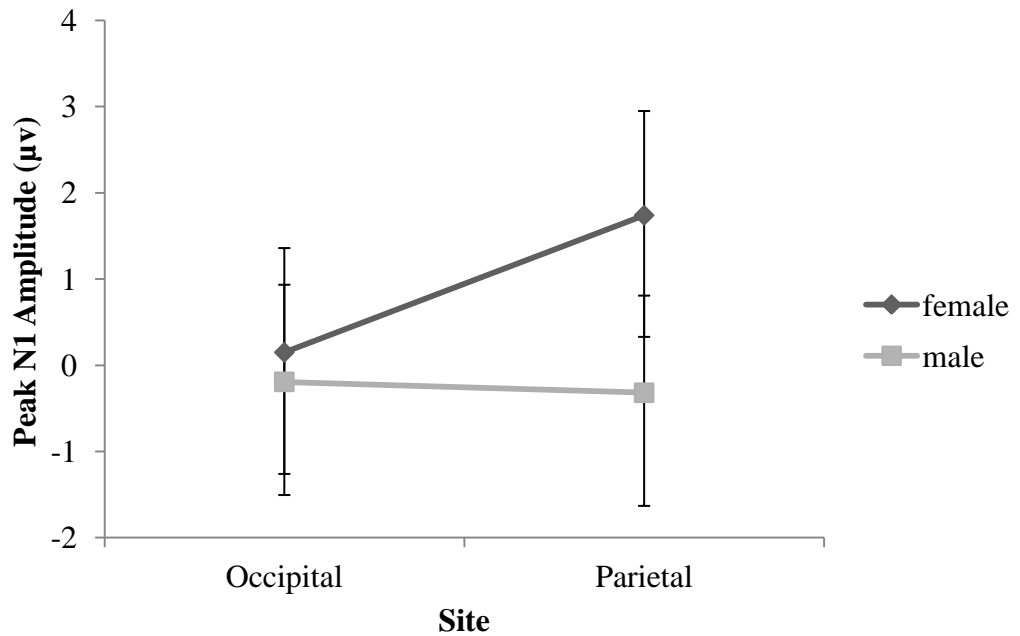


Figure 7. Peak N1 amplitude at Occipital and Parietal sites (error bars show 95% CI)

This interaction was modified by a significant Site \times Alerting \times Congruency \times Sex interaction, $F(1,26)=5.17$, $p=.032$, $\eta_p^2=.166$. An analysis of simple interaction effects ($\alpha=0.025$, Bonferroni adjusted) showed the Site \times Alerting \times Sex interaction was significant for incongruent trials, $F(1,26)=6.411$, $p=.018$, $\eta_p^2=.198$ (see Figure 8), but

not for congruent trials, $F(1,26)=0.20$, $p=.662$, $\eta_p^2=.007$. Further examination of this interaction on incongruent trials ($\alpha=.016$, Bonferroni adjusted) showed that the Site \times Sex interaction was significant on non-alerting trials, $F(1,26)=19.95$, $p<.001$, $\eta_p^2=.434$, but not alerting trials, $F(1,26)=6.40$, $p=.018$, $\eta_p^2=.197$. Between subjects effects demonstrated that at parietal sites for non alerting, incongruent trials, males ($M=-.336$, $SD=2.65$, 95% CI [-1.743, 1.071]) had a more negative N1 amplitude compared to females ($M= 2.26$, $SD=2.65$, 95% CI [.747, 3.770]), $F(1,26)=6.67$, $p=.016$, *Hedges g*=.951. There were no other theoretically relevant higher order interactions.

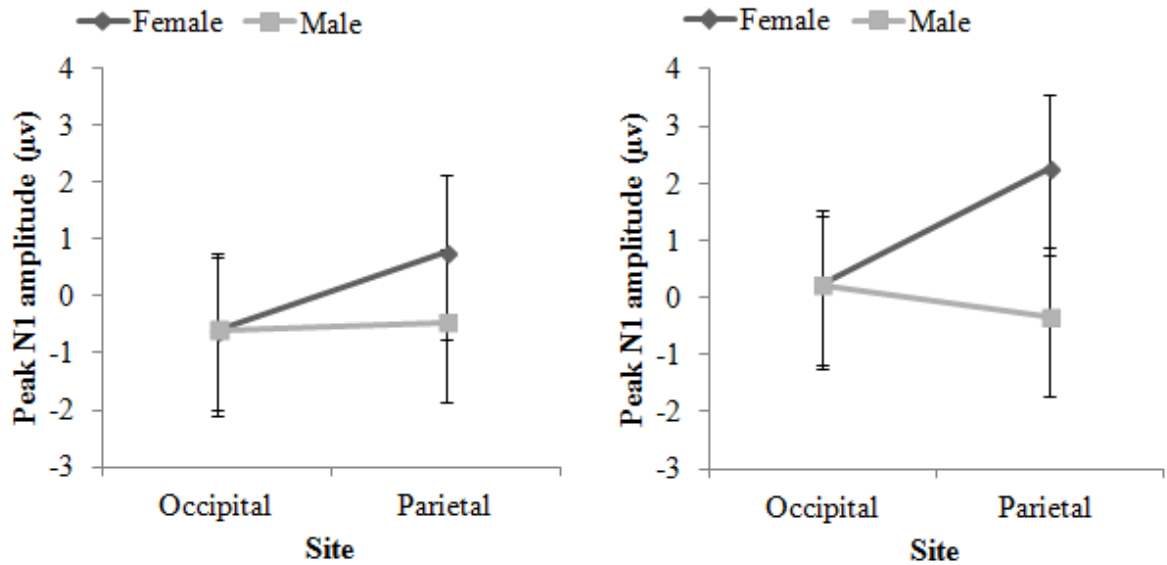


Figure 8. Peak N1 amplitude for alerting (left) and non-alerting (right) trials at occipital and parietal sites for males and females (error bars represent 95% CIs).

Peak N2 amplitude. The main effect of Alerting was non-significant, $F(1,26)=2.893$, $p=.101$, $\eta_p^2=.100$. The Alerting \times Sex interaction was non-significant, $F(1,26)=.362$, $p=.552$, $\eta_p^2=.014$. There was a significant main effect of Cue, $F(1,26)=4.614$, $p=.041$, $\eta_p^2=.151$, whereby valid trials elicited significantly greater N2

amplitudes ($M=1.25$, $SD=3.60$, 95% CI [-0.15, 2.65]) compared to invalid trials ($M=2.126$, $SD= 3.00$, 95% CI [0.96, 3.29]). However, the Cue \times Sex interaction was non-significant, $F(1,26)=.587$, $p=.451$, $\eta_p^2=.022$.

The main effect of Congruency was non-significant, $F(1,26)= 0.398$, $p=.534$, $\eta_p^2=.015$. Similarly, the Congruency \times Sex interaction was non-significant, $F(1,26)=0.838$, $p=.368$, $\eta_p^2=.031$. Additionally the main effect of Hemisphere was non-significant, $F(1,26)=0.540$, $p=.469$, $\eta_p^2=.020$, as was the Hemisphere \times Sex interaction, $F(1,26)=.898$, $p=.352$, $\eta_p^2=.033$. The Cue \times Congruency \times Hemisphere \times Sex interaction was significant, $F(1,26)= 5.017$, $p=.034$, $\eta_p^2=.262$. Further examination of this interaction demonstrated that the Cue \times Congruency \times Sex interaction was significant in the right hemisphere (P4), $F(1,26)=5.18$, $p=.031$, $\eta_p^2=.166$, but not the left hemisphere (P3), $F(1,26)=0.09$, $p=.762$, $\eta_p^2=.004$ (see Figure 9). Analysis of simple interaction effects ($\alpha=.025$, Bonferroni adjusted) showed that the Congruency \times Sex interaction was approaching significance at the right parietal site on valid trials, $F(1,26)=5.169$, $p=.031$, $\eta_p^2=.166$, but not for invalid trials, $F(1,26)=0.65$, $p=.426$, $\eta_p^2=.023$ (see Figure 9). Further examination showed that for congruent valid trials in the right hemisphere, females had a significant effect of Congruency, $F(1,26)=15.34$, $p=.002$, $\eta_p^2=.561$, whereas males had a non-significant effect of Congruency, $F(1,26)=0.04$, $p=.845$, $\eta_p^2=.003$.

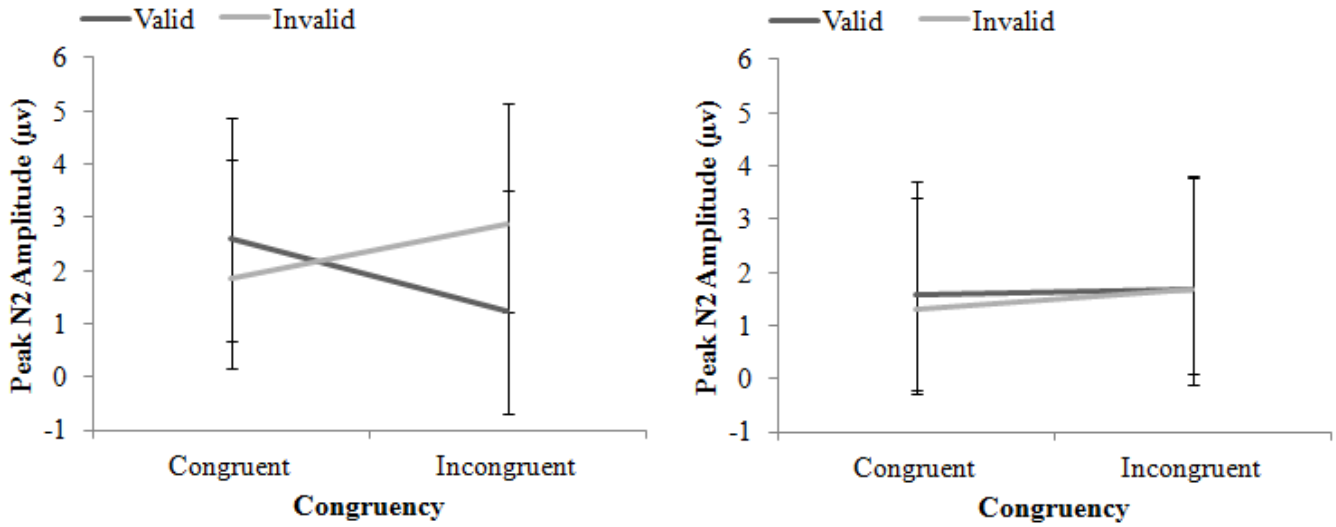


Figure 9. Peak N2 amplitude for females (left) and males (right), in the right parietal site (P4), on congruent and incongruent trials for valid and invalid cues (error bars represent 95% CIs).

There was a significant Cue \times Hemisphere interaction, $F(1,26)=23.20$, $p<.001$, $\eta_p^2=.472$. Analysis of simple interaction effects ($\alpha=.025$, Bonferroni adjusted) demonstrated that for the Cue \times Hemisphere interaction was significant for congruent, $F(1,26)=30.81$, $p<.001$, $\eta_p^2=.542$, but not for incongruent trials, $F(1,26)=4.55$, $p=.042$, $\eta_p^2=.149$. Analysis of simple main effects ($\alpha=.016$, Bonferroni adjusted) showed that the main effect of Cue was significant for congruent trials in the left hemisphere, $F(1,26)=13.92$, $p=.001$, $\eta_p^2=.349$, but not in the right hemisphere, $F(1,26)=1.22$, $p=.279$, $\eta_p^2=.045$. Pairwise comparisons ($\alpha=.012$, Bonferroni adjusted) for the congruent trial in the left hemisphere showed that valid cues had significantly greater N2 amplitudes

($M=0.84$, $SD=3.73$, 95%CI[-0.60,2.29]) compared to invalid cues ($M=2.56$, $SD=3.61$, 95%CI[1.16,3.96]), $p=.001$, Hedges $g=.462$.

Discussion

The aim of the current study was to clarify inconsistencies within the literature regarding sex differences in the attentional networks. The alerting, cueing and congruency effects were present in the results, whereby for both groups the alerting trials produced faster RTs than the non-alerting trials demonstrating the alerting effect. Further, the valid cues had a faster RT compared to the no cue and invalid cues, and the neutral cues yielded fast RTs compared to the invalid cues, demonstrating an overall orienting effect. Participants in both groups had faster RTs to congruent trials relative to incongruent trials, demonstrating a congruency effect which is argued to reflect processes of executive control.

Importantly, the main effect of cue was modulated by sex, whereby the effect sizes for the between groups difference (though non-significant) of the invalid and no cue trials were greater ($>.5$) relative to valid trials. Nonetheless, the results are preliminary and should be interpreted with caution, especially due to the non-significant findings. However, previous research looking at the orienting network using endogenous cueing, found that females showed a cost in RT for invalid cues whereas males showed a benefit (Merritt et al., 2009). Neuhaus et al. (2009) also found that overall females had slower RTs compared to males in an ANT. In the current study females had slower RTs to invalid and no cue trials compared to males, while these effect was non-significant there were moderate effect sizes. The sex difference in the no cue condition was not predicted but may be explained by mechanisms associated with reorienting of attention

(Galvao-Carmona et al., 2014; McConnell and Shore, 2011). These findings provide preliminary support for the reorienting hypothesis which has been discussed in previous literature but has not been applied to sex differences in the orienting network.

Additionally, the prediction that there would be no sex differences in the P1 component, which indexes the orienting network, was partially supported. There was no main effect of sex, nor was there a significant Cue \times Sex interaction which would be expected for the orienting network. However, break down of the significant Hemisphere \times Cue \times Congruency \times Site \times Sex interaction demonstrated that at the right hemisphere occipital site females had greater P1 amplitudes relative to males for invalid, congruent trials. While it is important not to over analyse this higher order interaction, the finding, though not predicted, is consistent with findings associated with inhibition of return (Chica & Lupianez, 2009).

After examination of the N1 amplitude, which is also associated with the orienting network, it was found that the hypothesis that females would have greater amplitudes for invalid trials relative to males was not supported. Conversely, an examination of a significant Sex \times Site interaction revealed that at parietal sites males had greater N1 amplitudes relative to females overall and this effect was greatest on incongruent, non-alerting trials. However, modulation in the N1 amplitude did not differ between sexes according to cue type.

Consistent with previous research it was expected that females would have a slower RT to incongruent trials relative to males due to a greater distraction of irrelevant information (Stoet et al., 2010). However, the findings of the present study did not support this hypothesis; rather the congruency effect was not modulated by sex. While

there were no behavioural findings that support a sex difference in the executive control network, the electrophysiological finding of modulations in the N2p amplitudes for females relative to males may suggest otherwise. Conci et al. (2006) used a visual search/detection task and found that the N2p increased in response to trials when there were distracters present (Conci, Gramann, Muller, & Elliott, 2006). While this task is different from an ANT, similar cognitive mechanisms may be employed in an ANT when distracters are present in incongruent trials.

Orienting Network

The faster RT yielded by male participants for invalid cues is consistent with the academic literature whereby males have been shown to out perform females on visuo-spatial tasks (Bell et al., 2005). For example, Merritt et al. (2009) found that in an endogenous cueing paradigm males had a benefit in RT for invalid trials where as females showed a cost in RT. It was suggested that this may be because males more effectively disengage from the invalidly cued location for target detection. Neuhaus et al. (2009) used an ANT and found a trend for an overall slower performance by female participants, however not at a statistically significant level.

The finding that males were significantly faster to respond to neutral trials relative to females may be explained by a mechanism discussed by Galvao-Carmona et al. (2014). It was suggested that females have a more global distribution of their attention, and therefore take longer to respond to a neutral cue relative to males. Alternatively, it may be that males have a more global spread of their attentional focus, meaning they respond faster to a no cue trial as their attention is already spread across all possible spatial locations of the proceeding target stimulus.

The hypothesis that females would have greater N1 amplitude for invalid trials relative to males was not supported. These predictions were based on previous findings in the literature, whereby, in an ANT females had greater N1 amplitudes in response to spatial cues (double cue) compared to males (Neahuas et al., 2009). Additional research looking at the orienting network using alternative paradigms found similar results. For example, Vaquero et al. (2004) used an oddball task and found that females had a greater N1 when discriminating a target relative to males. Merritt et al. (2007) suggested that findings of this nature may imply that females attend more to cues and therefore less effectively reorient their attention to the target location, eliciting slower RTs and greater N1 amplitudes. Conversely, the results of the current study showed that for all trial types, at parietal sites males had significantly greater N1 amplitudes compared to females, an effect that was greatest for incongruent, non alerting trials.

While this higher order interaction should be interpreted with caution, these findings may be explained by findings that suggest greater N1 amplitudes to valid rather than invalid trials. In the present study, there was a trend of faster RTs for males compared to females for invalid and no cue trials (moderate effect sizes), additionally males also had a greater N1 amplitude regardless of trial type. Hillyard et al. (1998) looked at covert shifts of attention and found that N1 amplitude was greater to attended versus unattended location (Sauseng et al., 2005 found similar results). The combination of faster RTs and greater N1 amplitudes to valid trials relative to invalid trials may suggest that the increased efficiency to respond requires greater attentional resources, resulting in faster response times and greater amplitudes (Hillyard & Anllo-Vento, 1998). Following this line of reasoning it may be plausible to suggest that the greater N1

amplitude at parietal sites found in males in the current study could be due to the behavioural finding that males tended to have faster RTs than females, and therefore had greater activation of cognitive resources (Hillyard & Anllo-Vento, 1998).

There is evidence to suggest that greater N1 amplitudes are associated with more global attentional focus, suggesting that males have a more global spread of attention eliciting faster RT to no cue and invalid trials. Specifically, the greater N1 amplitude and faster RT in males relative to females suggests that males recruit greater cognitive resources for a global attentional focus, eliciting faster RTs and greater N1 amplitudes to invalid and no cue trials.

Executive Control

The results of the current study demonstrated that participants were slower to respond to trials that had incongruent relative to congruent flankers, however, this was not modulated by sex. According to Eriksen & Eriksen (1974), who first proposed the flanker paradigm, visual noise disrupts the processing of a target stimulus. The presence of incongruent flankers results in interference and response competition, whereby the individual is required to select the target from the flanker resulting in RT costs. In the current study, it was hypothesised that females would be slower to respond to incongruent trials based on previous research looking at the executive control network using flanker and go/no-go tasks (Clayson et al., 2011; Stoet et al., 2010). One theory suggested that females may be more distracted by irrelevant information and therefore slower to respond. Alternatively, it was proposed that females have a less effective recruitment of attentional resources. However, in the current study there were no sex differences in response to incongruent trials, this finding is in line with other research

using ANTs to analyse the executive control network (Liu et al., 2013; Neuhaus et al., 2009). While Neuhaus et al. found an overall trend for slower RTs in females there was no significant difference for incongruent trials. Similarly, Liu et al. did not find a significant sex difference in RT for incongruent trials. Importantly, Liu et al. suggested that the executive control network is involved in endogenous but not exogenous cueing, which may explain the lack of sex differences in research using ANTs, which typically involve a spatial rather than symbolic cuing stimulus. Bayliss et al. (2005) found that sex differences only occurred in endogenous cueing and not exogenous cueing tasks.

Fan et al. (2002) suggested that the alerting and orienting effects in an ANT can modulate the degree of interference produced by the flankers. As such, it may be that while there is still an adequate level of interference from the flankers to produce a congruency effect, there may not be enough to produce a sex difference in an ANT. This explanation seems reasonable as research using paradigms other than the ANT to examine the executive control network have found a sex difference in response to incongruent trials (such as the flanker and go/no-go tasks). This explanation may also clarify the inconsistent findings regarding the N2 ERP component.

The N2 ERP component has been used to examine executive control processes. The congruency of the distracter is argued to modulate the frontal N2 amplitude such that an incongruent trial elicits greater amplitudes relative to congruent trials reflecting the need to suppress irrelevant information in the incongruent condition. Effects of this kind are suggested to reflect control processes in the ACC (van Veen & Carter, 2002). Research using a flanker task has demonstrated that females had a combination of a slower RT and greater N2 amplitude in response to incongruent trial relative to males

(Clayson et al., 2011). Suggesting that perhaps female are more distracted by the irrelevant information and therefore require greater attentional resources, eliciting greater N2 amplitude compared to males. However, the findings of the current study did not support this hypothesis. The congruency effect was not reflected in the frontal N2 component in the current study, and as such, these analyses were not conducted, and it was not possible to test these hypotheses.

It was however, possible to examine the N2 component elicited at parietal sites, and sex differences were demonstrated for valid trials. The N2p has been suggested to index reorienting of attention and stimulus classification, which suggests that this component may be associated more with the orienting network rather than the executive control network. Further support for this hypothesis is that the modulation in the N2p was due to a main effect of cue.

The lack of sex differences in the behavioural results for congruency may explain the lack of a finding concerning the frontal N2 component. It has been suggested that the increased N2 amplitude in response to congruency is associated more with the need to control incorrect response preparation rather than stimulus mismatch (Folstein & Petten, 2007). If this hypothesis were accurate, modulations in the N2 component would not be found in response to incongruent targets in the present paradigm.

Limitations and Implications

The current study is limited by the lack of control for hormone status in female participants. Due to the small sample size it is unlikely that a normal distribution of sex hormones could be assumed. There is evidence to suggest that sex hormones effect cognitive function differently at varying stages of the menstrual cycle (Hampson, 1990).

Another limitation to the small sample size of the current study is the potential lack of generalisation of the results, especially as our sample was relatively homogenous in terms of education and age. Importantly, the sample of the current study was predominantly first year psychology students with a mean age of 22.1. Differences in ERP modulations using an ANT have been found between children and adults (Abundis-Gutierrez et al., 2014). Considering the relative youth of this sample the developmental differences in cognitive function between males and females should be taken into account.

Additionally, while the current study did not include spider stimuli the experimental task was conducted in sequence with tasks looking at spider fear. While the participants recruited were predominantly from a low spider fear sample, it has been suggested that females are generally more prone to anxiety than males and attend more to threat than males. As such, carry over effects from the previous task involving spider stimuli may have affected the results. As such, it may be beneficial for future research to consider stimulus salience in an ANT and examine sex differences. Additionally, due to the possibility that the findings of the current study were influenced by interaction effects of the networks future research should consider the interactions between the attentional networks and any associated sex differences. In addition to this, significant interactions were found that involved hemisphere, previous research has suggested that there may be sex differences in lateralization of attention (Falasca et al., 2015; Asanowicz, Marzecova, Jaskowski, & Wolski, 2012). However, this has not been explored in an ANT, therefore future research may benefit from examining sex difference in hemispheric lateralization of the attentional networks.

Further, the finding that males were more likely to report that they ‘often’ played video games compared to females may have influenced the findings of the current study. It is possible that due to practice effects associated with gaming experience males were faster to respond to the computer based task relative to females. As such, future research could benefit from examining the effect of gaming experience on attention.

Importantly, the small sample size may have influenced the results of the current study due to a potential lack of power to detect differences. The presence of moderate to large effect sizes in between group comparisons in the current study suggest that the behavioural indices of the attentional networks could potentially be significant with a larger sample size.

Summary and Conclusions

In summary, the purpose of the current study was to clarify sex differences in the behavioural and electrophysiological measures of the attentional networks proposed by Petersen and Posner (2012), using an ANT. Males had a trend for faster RTs to neutral and invalid trials with moderate effect sizes, and had greater N1 amplitudes compared to females, demonstrating a greater orienting effect compared to females. Theoretically, this may be because males have a more global spread of their attentional resources allowing faster re-orienting to a target location. These findings support the hypothesis that there are sex differences in the orienting network, which is consistent with previous findings of stronger visuo-spatial performance in males relative to females (Bell et al., 2005). While the current study found no sex differences in the congruency effect this may be due to interference of the alerting and orienting network. Interactions between the three networks were demonstrated in the current study, which supports findings in

previous literature (Fan et al., 2002). Specifically, it has been suggested that the congruency effect of the ANT is altered due to interaction with the orienting and alerting network. Due to the scope of the current study the effect of these interactions could not be fully explored. The findings of the current study lend support to the notion that there are sex differences in the behavioural and electrophysiological indices of the attentional networks. However, future research needs to be conducted to clarify the preliminary outcome of the current study, taking into consideration possible sex differences in the interaction between networks.

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Appendices

Appendix A

Ethics Approval letter

Social Science Ethics Officer
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Human.ethics@utas.edu.au



HUMAN RESEARCH ETHICS COMMITTEE (TASMANIA) NETWORK

12 March 2015

Dr Allison Matthews
Psychology
Private Bag 30

Sent via email

Dear Dr Matthews

Re: APPROVAL FOR AMENDMENT TO CURRENT PROJECT
Ethics Ref: **H0011104 - The effects of real versus hyper-real images on computer-based exposure treatment for spider phobia**

1. Removal of Honours students Rebecca Venettacci and Emma Robards.
2. Addition of Honours students Isobel Hoystead, Amber Johnstone, and Shelley Flynn.
3. Modification to the attentional tasks used in the study.
4. Addition of male participants (high and low spider fear groups).
5. Screening questionnaire will now be completed online.
6. Refinement of screening questionnaire including the addition of a trait anxiety measure, the K10, and the AUDIT.
7. Addition of a trait anxiety assessment and a test of adult reading on the day of the experimental session.

We are pleased to advise that the Chair of the Tasmania Social Sciences Human Research Ethics Committee approved the Amendment to the above project on 12/3/2015.

Yours sincerely

A handwritten signature in blue ink, appearing to be 'KShaw', is written above the printed name of Katherine Shaw.

Katherine Shaw
Executive Officer
Tasmania Social Sciences HREC

Appendix B

Screening Questionnaires

Screening Questionnaire

Section 1 - Demographics

1. Age _____

2. Sex _____

3. Females only:

Are you currently on the contraceptive pill? **Yes / No**

Are you currently pregnant or breastfeeding? **Yes / No**

Is there any possibility that you could be pregnant? **Yes / No**

4. Is English your first language? **Yes/no?**
(if no please specify _____)

5. Are you left or right handed? **Right [1] Left [2]**

6. What grade of school did you complete?

Year _____

7. Have you completed any courses after school?

No.....0

Yes, trade/technical.....1

Yes, university.....2

Specify qualifications _____

8. Are you currently studying?

No.....0

Yes, trade/technical.....1

Yes, university..... 2

Specify _____

Section 2 – Spider fear

Spider Phobia Questionnaire

Please indicate whether you do any of the following behaviours by marking the appropriate box. Work quickly and don't spend too much time over any question. Please answer every question truthfully.

	YES	NO
1. Do you check the lounge for spiders before sitting down?		
2. Can you deal effectively with spiders yourself when you find them?		
3. Do you sometimes dream about spiders?		
4. Do you ever make plans in case you come across a spider?		
5. Do you sometimes look at the corners of the room for spiders?		
6. Do you get other people to get rid of spiders when you find them?		
7. Do you think a lot about spiders?		
8. Would you know how to cope with spiders in the bath?		
9. When watching television, would you notice a spider crawling across the floor elsewhere in the room?		
10. Do you sometimes use a book or a newspaper to deal with a spider?		
11. Do you worry more about spiders than most people?		
12. Do you feel a lot more secure if someone else is in the house, in case you come across a spider?		
13. When you imagine a spider, can you see parts of it in great detail?		
14. Do you check the bedroom for spiders before going to bed?		
15. When you find a spider in the room, would you avoid going in that room until someone else has removed it?		
16. Do you ever find yourself thinking about spiders for no reason?		
17. Would you get help if you came across a spider?		
18. Do you sometimes find it an effort to keep thoughts of spiders outside your		

mind?		
19. Would your mind be a lot easier if spiders didn't exist?		
20. Are you always on the lookout for spiders?		
21. Do you often think about particular parts of spiders for example their fangs?		
22. If you find a spider in the bath, would you, say, use a shower to wash the spider down the plughole?		
23. Are you sometimes distracted by thoughts of spiders?		
24. Have you a "plan for action" in case you find a spider in the kitchen?		
25. Are you sometimes haunted by thoughts of spiders?		
26. Do you make certain that there are no spiders around before taking a bath?		
27. If you discover a spider in the room, do you leave the room straight away?		
28. When watching television do you think more about the danger of a spider being in the room than about the program?		
29. Do you sometimes sense the presence of a spider without actually seeing it?		
30. If there's a spider in the house, are you the most likely person to find it?		
31. Have you had nightmares about spiders?		
32. Would you think about using a broom to deal with a spider in the kitchen?		
33. Can you spot a spider out of the corner of your eye?		

Fear of Spiders Questionnaire

Please indicate your answer by ticking the box that best describes your response.

	1 Definitely not	2	3	4	5	6	7 Absolutely
1. If I came across a spider now, I would get help from someone else to remove it.							
2. Currently, I am sometimes on the lookout for spiders.							
3. If I saw a spider now, I would think it will harm me.							
4. I now think a lot about spiders.							
5. I would be somewhat afraid to enter a room now, where I have seen a spider before.							
6. I now would do anything to try to avoid a spider.							
7. Currently, I sometimes think about getting bitten by a spider.							
8. If I encountered a spider now, I wouldn't be able to deal effectively with it.							
9. If I encountered a spider now, it would take a long time to get it out of my mind.							
10. If I came across a spider now, I would leave the room.							
11. If I saw a spider now, I would think it will try to jump on me.							

12. If I saw a spider now, I would ask someone else to kill it.							
13. If I encountered a spider now, I would have images of it trying to get me.							
14. If I saw a spider now I would be afraid of it.							
15. If I saw a spider now, I would feel very panicky.							
16. Spiders are one of my worst fears							
17. I would feel very nervous if I saw a spider now.							
18. If I saw a spider now I would probably break out in a sweat and my heart would beat faster.							

Section 3 – Health and Medical History

1. Have you ever suffered from any of the following:

Epilepsy	Yes	No
Severe head injury	Yes	No
Diabetes	Yes	No
Fits or convulsions (that were not related to a fever)	Yes	No
Loss of consciousness (greater than 2 minutes)	Yes	No
Concussion in last 6 weeks	Yes	No
Regular Giddiness	Yes	No
Heart condition or any other serious physical condition	Yes	No
Sleep disorder (or any major sleeping difficulties)	Yes	No
Visual problems (that are not fixed with glasses/contact lenses)	Yes	No
Hearing problems	Yes	No

If you answered yes to any of the questions above, please provide some extra information on the condition (and the length of time and severity).

2. Are you currently taking any prescribed medications? Yes / No

If yes, please specify:

.....

3. Do you have sensitive skin? Yes / No

(Skin preparation for EEG recording includes using alcohol wipes and exfoliant in order to get the best reading possible from electrodes, people with sensitive skin may find this irritating)

Section 4 – Mental health**1. Have you ever been diagnosed with a mental health condition? Yes / No**

If yes, please provide some extra information (including the condition and time frame):

.....

.....

.....

2. Have you ever been prescribed medications for mental health problems? Yes / No

If yes, please state which medications and how long ago

.....

.....

.....

.....

Kessler Psychological Distress scale (K10)

In the last 4 weeks, about how often:

1. Did you feel tired out for no good reason?

All of the time.....1
 Most of the time.....2
 Some of the time.....3
 A little of the time.....4
 None of the time5

2. Did you feel nervous?

All of the time.....1
 Most of the time.....2
 Some of the time.....3
 A little of the time.....4
 None of the time5

Note: If response 5 chosen, go to Q4

3. Did you feel so nervous that nothing could calm you down?

All of the time.....1
 Most of the time.....2
 Some of the time.....3
 A little of the time.....4
 None of the time5

4. Did you feel hopeless?

All of the time.....1
 Most of the time.....2
 Some of the time.....3
 A little of the time.....4
 None of the time5

5. Did you feel restless or fidgety?

All of the time.....1
 Most of the time.....2
 Some of the time.....3
 A little of the time.....4
 None of the time5

Note: If response 5 chosen, go to Q7

6. Did you feel so restless that you could not sit still?

All of the time.....1

Most of the time.....2

Some of the time.....3

A little of the time.....4

None of the time.....5

7. Did you feel depressed?

All of the time.....1

Most of the time.....2

Some of the time.....3

A little of the time.....4

None of the time.....5

8. Did you feel that everything was an effort?

All of the time.....1

Most of the time.....2

Some of the time.....3

A little of the time.....4

None of the time5

9. Did you feel so sad that nothing could cheer you up?

All of the time.....1

Most of the time.....2

Some of the time.....3

A little of the time.....4

None of the time5

10. Did you feel worthless?

All of the time.....1

Most of the time.....2

Some of the time.....3

A little of the time.....4

None of the time

Section 5 – Substance use

The following questions are about your use of tobacco, alcohol and other substances

1. In the last 6 months, how often have you used tobacco/nicotine?

Never0

Less than monthly1

Monthly2

Weekly3

Daily or almost daily4

2. In the last 6 months, how often have you used illicit drugs (e.g., cannabis, ecstasy, speed)?

Never0

Less than monthly1

Monthly2

Weekly3

Daily or almost daily4

3. On how many occasions have you ever used illicit drugs?

None0

1-51

5-102

10-153

More than 15 occasions4

AUDIT

Q1. How often do you have a drink containing alcohol?

Never.....0

(Go to Q9)

Monthly or less1

2–4 times per month.....2

2–3 times per week.....3

4 or more times a week.....4

Q2. How many drinks containing alcohol do you have on a typical day when you are drinking?

1 or 2.....0

3 or 4.....1

5 or 6.....2

7 to 9.....3

10 or more4

Q3. How often do you have six or more drinks on one occasion?

Never.....0

Less than monthly.....1

Monthly.....2

Weekly3

Daily or almost daily4

Q4. How often during the last year have you found that you were unable to stop drinking once you had started?

Never.....0

Less than monthly.....1

Monthly.....2

Weekly3

Daily or almost daily4

Q5. How often during the last year have you failed to do what was normally expected from you because of drinking?

Never.....0

Less than monthly.....1

Monthly.....2

Weekly3

Daily or almost daily4

Q6. How often during the last year have you needed a first drink in the morning to get yourself going, after a heavy drinking session?

Never.....0

Less than monthly.....1

Monthly.....2

Weekly3

Daily or almost daily4

Q7. How often during the last year have you had a feeling of guilt or remorse after drinking?

Never.....0

Less than monthly.....1

Monthly.....2

Weekly3

Daily or almost daily4

Q8. How often during the last year have you been unable to remember what happened the night before because you had been drinking?

Never.....0

Less than monthly.....1

Monthly.....2

Weekly3

Daily or almost daily4

Q9. Have you or someone else been injured as a result of your drinking?

No.....0

Yes, but not in the last year2

Yes, during the last year4

Q10. Has a relative or friend or doctor or other health worker been concerned about your drinking or suggested you cut down?

No.....0

Yes, but not in the last year2

Yes, during the last year4

Appendix C

Experimental Session Questionnaires

Note to interviewer: When booking, ask participant not to consume caffeine (2 hrs), tobacco (2hrs), alcohol (24 hours) and illicit drugs (none) prior to session, and let them know that they may have some residual electrode gel in their hair when they leave the session

Experimental session questions

(To be completed on the day of the experimental session)

Date ____/____/____

Participant ID

1. **Check that participant has abstained from alcohol for 24 hours and illicit drug use since completing the screening questionnaire**
3. **How many cups of coffee (or any other caffeinated drinks/products) have you consumed today? _____**
If > 0. How many hours since your last caffeinated drink _____ hours
4. **Have you had any tobacco or nicotine products today? Yes / No**
If yes, how many cigarettes (or nicotine products) have you had today? ____
If yes, How many hours since your last cigarette (nicotine product) _____ hours
5. **Have you consumed any medications in the past week (or any prescribed medications since completing the screening questionnaire)?**

If yes, please detail:

Medication	Number of occasions	Time since last used	Estimated dose

6. Approximately how many hours sleep did you have last night? ____

Karolinska sleepiness scale (participant can self-complete)

Please circle on the following scale of 1 to 9 how you feel **AT THE PRESENT MOMENT**:

1	2	3	4	5	6	7	8	9
Very alert		Alert – normal level		Neither alert nor sleepy		Sleepy – but no effort to stay awake		Very sleepy, great effort to stay awake, fighting

Menstrual Cycle Form

Date:

Participant:

What was the date of the first day of your last period? If you don't remember the

exact date you can give an approximate range (e.g. 5-8 May):

April 2015

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

May 2015

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

June 2015

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

July 2015

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Date: _____

Participant: _____

Video Gaming Experience Questionnaire

We are interested in how often you play video games, and may use this information to examine the effects of video game playing on visual attention and motor skills.

How often would you normally play video games? Please choose one response.

- ☐ Never play video games
- ☐ Rarely play video games (less than 2 hours a month)
- ☐ Occasionally play video games (between 30 minutes and 2 hours a week)
- ☐ Regularly play video games (between 2 hours and 5 hours a week)
- ☐ Often play video games (more than 5 hours a week)

Appendix D

Participant Information and Consent Form

PARTICIPANT INFORMATION SHEET

Spider Fear, Brain Activity, and Attention

Invitation

You are invited to participate in a research study into the effects of spider fear on attention during the viewing of spider images. This is an Honours study being conducted by Isabel Hoystead, Amber Johnstone, and Shelley Flynn under the supervision of Dr Allison Matthews (Chief Investigator, School of Medicine, Psychology).

1. 'What is the purpose of this study?'

The purpose is to investigate brain processes involved in attentional processing among males and females with high and low spider fear.

2. 'Why have I been invited to participate in this study?'

You are eligible to participate in this study because you have an intense fear of spiders or that you have a relatively low of fear spiders.

3. 'What does this study involve?'

This study will require you to attend one session (approximately 2 hours) at the University of Tasmania. In this session you will complete some questionnaires relating to your fear of spiders. You will then complete some computer tasks where you will respond (using a button press) to particular aspects of visual stimuli presented on a computer screen. These stimuli may include pictures, letters or objects (and may include pictures of spiders). Your brain activity will be measured while you complete these tasks.

It is important that you understand that your involvement in this study is voluntary. While we would be pleased to have you participate, we respect your right to decline. There will be no consequences to you if you decide not to participate, and this will not

affect your relationship with the University. If you decide to discontinue participation at any time, you may do so without providing an explanation. All information will be treated in a confidential manner, and your name will not be used in any publication arising out of the research. All of the research will be kept in a locked cabinet in the office of Dr Allison Matthews or on a secure server at the University of Tasmania.

4. Are there any possible benefits from participation in this study?

You may or may not experience anxiety during the course of the study. However, if you do, it is hoped that you will notice a reduction in your anxiety after a certain period of time. The results of this study will provide valuable information on the attentional processes involved in spider fear and will help us to further develop an online treatment program for people with phobias.

5. Are there any possible risks from participation in this study?

If you experience anxiety during the study, this may be unpleasant and include emotions of fear and worrying thoughts, wishing to avoid the situation, physical discomforts such as palpitations, sweating and over-breathing. The researchers will provide you with information for coping with these symptoms if they unduly trouble you. However, if you find that you are becoming distressed or experience significantly elevated levels of anxiety you will be advised to receive support from a clinician or alternatively, we will arrange for you to see a counsellor at no expense to you..

There are no specific risks associated with the measurement of brain activity. However, if you have sensitive skin there is a small possibility of a slight skin reaction from electrode preparation materials. If you believe there is a chance that your skin may react you are advised to reconsider participation.

6. What if I have questions about this research?

If you would like to discuss any aspect of this study, or require further assistance with your fear of spiders after the study is completed, please feel free to contact Dr Allison Matthews on (03) 62267236, who would be happy to discuss any aspect of the research with you. Once we have analysed the information we will be putting a summary of our

findings on the School of Psychology website for you to view. You are welcome to contact us at that time to discuss any issue relating to the research study.

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study should contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. You will need to quote [H0011104].

Thank you for taking the time to consider this study. If you wish to take part in it, please sign the attached consent form. This information sheet is for you to keep.

Coping with Anxiety

The Nature of Anxiety

Anxiety is a normal and healthy reaction that allows you to deal with threat or danger. When you are confronted by a threatening situation your body automatically releases hormones which send signals to the body to prepare to 'fight' or 'flight'. We become more alert, our heartbeat speeds up, the muscles get tense ready for action, sweating increases to cool the body, and breathing rate speeds up so that we can get oxygen into our bodies more quickly. These changes allow us to run very quickly or fight our enemies. Sometimes when our breathing rate increases, we tend to over breathe or hyperventilate. This hyperventilation may cause a number of symptoms including dizziness, breathlessness or chest pains. It is important to realise that these feelings are part of a physical response to threat and are not a sign that you have some physical disease. These symptoms do not mean that you will die, go crazy, or lose control.

Management of Anxiety

Although anxiety is a normal, and at times, a useful response, excessive anxiety may interfere with your everyday life. Anxiety can be managed by reversing or interrupting the flight-or-flight response through the use of breathing or relaxation techniques. To reduce symptoms of hyperventilation it is necessary to increase and steady the levels of carbon dioxide in the blood. One method to do this is breathing into a paper bag. Another method to reduce over breathing and to **prevent anxiety from escalating** is the slow breathing exercise (see below). This exercise can be practiced daily **and** used at any time that you notice sensations of anxiety.

Breathing Exercise

1. Hold your breath and count to 5 (do not take a deep breath).
2. When you get to 5, breathe out and say the word 'relax' in a calm soothing manner.
3. Breathe in and out slowly through your nose in a 6 second cycle (breathe in for 3 seconds & out for 3 seconds). This will produce a breathing rate of 10 breaths per minute. Say 'relax' to yourself when you breathe out.
4. At the end of each minute hold your breath for 5 seconds and then continue breathing using the 6 second cycle
5. Continue breathing this way until all of the symptoms of over breathing have gone.

Exposure Treatment for Anxiety

If your anxiety is associated with specific objects or situations (such as spiders) it is also possible to reduce anxiety through exposure to the feared object or situation. **It is important to remain in the feared situation until there is a decrease in anxiety. Although your anxiety may rise when confronting the situation, it will also fall within a few minutes.** By remaining in the situation you will learn that there is nothing to fear.

What do I do if I am experiencing high levels of anxiety during the treatment?

If you are feeling anxious during the treatment, try to remain calm and do the above breathing exercise. Remember your anxiety will fall in a few minutes. If your anxiety becomes overwhelming, you are free to stop the treatment. If you are undertaking a session in the research clinic you will be assisted by the researchers to regain your composure. You do not have to continue with the treatment if you do not wish to.

If your anxiety becomes overwhelming when you are completing the treatment at home, again, try to remain calm and do the above breathing exercise. Remember your anxiety will fall in a few minutes. If you choose to stop following a circle on the screen with the computer mouse, the stimulus on the screen will disappear. This will allow you time to regain your composure. When you are ready to start again, you can start following the circle and the image will reappear. Again you are free to stop the treatment at any stage. You may like to enlist the help of a friend or relative, by showing them this information, they may be able to assist you should the need arise. If you are hyperventilating and the breathing exercise does not help, you may like to have a paper bag handy that you can breathe into. This will help to stop you from over breathing.

What if I need further help or treatment?

Please note that this information is NOT a substitute for diagnosis and treatment by an appropriate health professional. Please let us know if you require further assistance and we can refer you to an appropriate health professional. Your GP will also be able to refer you for further assessment and treatment if required.

The School of Medicine (Psychology), University of Tasmania, is not a health or crisis service and does not have the capacity to provide clinical advice or assistance if you require these services. **If you need urgent medical or psychological assistance, please contact your local doctor/GP or other health professional, or the emergency department of your local hospital.**

Coping with Anxiety (for researchers)

Dealing with anxiety during treatment

1. Be familiar with the above information on the nature of anxiety and its management. Go through this information with participants and answer any questions that they may have.
2. Allow participants to work through their anxiety unless they become particularly distressed and indicate that they wish to stop the treatment, in which case exit the program for them and reassure them that this is ok.
3. Ask them to concentrate on breathing slowly and regularly and perhaps work through the above breathing exercise.
4. If the participant is hyperventilating and the breathing exercise has not worked, assist participant to breathe into a paper bag.
5. It is probably best that the participant does not leave until their anxiety has subsided. They may like a decaffeinated drink.
6. In the case that the above measures have not been helpful contact the consulting psychiatrist, Prof. Kenneth Kirkby on 0419120041

Referral

If participants request referral for specialised treatment, discuss with Prof. Ken Kirkby, who will arrange appropriate referral.

CONSENT FORM

Spider Fear, Brain Activity, and Attention

1. I have read and understood the 'Information Sheet' for this project.
2. The nature and possible effects of the study have been explained to me.
3. I understand that the study involves attending one session (approx. 2 hours) at the University of Tasmania whereby I will complete some questionnaires and some computer based attention tasks. These tasks may involve responding to pictures (including spiders), letters, or objects and brain activity will be monitored throughout the process.
4. I understand that participation involves some risk of experiencing a heightened level of anxiety; however, the researcher will be present at all times, I will be given information on how to cope with anxiety, and I will be referred to a counsellor if need be. I understand that measurement of brain activity involves minimal risk, and slight skin irritation may occur if I have sensitive skin.
5. I understand that all research data will be securely stored on the University of Tasmania premises for ten years and will then be destroyed.
6. Any questions that I have asked have been answered to my satisfaction.
7. I agree that research data gathered from me for the study may be published provided that I cannot be identified as a participant.
8. I understand that the researchers will maintain my identity confidential and that any information I supply to the researcher(s) will be used only for the purposes of the research.
9. I agree to participate in this investigation and understand that I may withdraw at any time without any effect, and if I so wish, may request that any data I have supplied to date be withdrawn from the research.

Name of Participant:

Signature:

Date:

Statement by Investigator

☐

I have explained the project & the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation

If the Investigator has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have the opportunity to contact me prior to consenting to participate in this project.

Name of Investigator

Signature of Investigator